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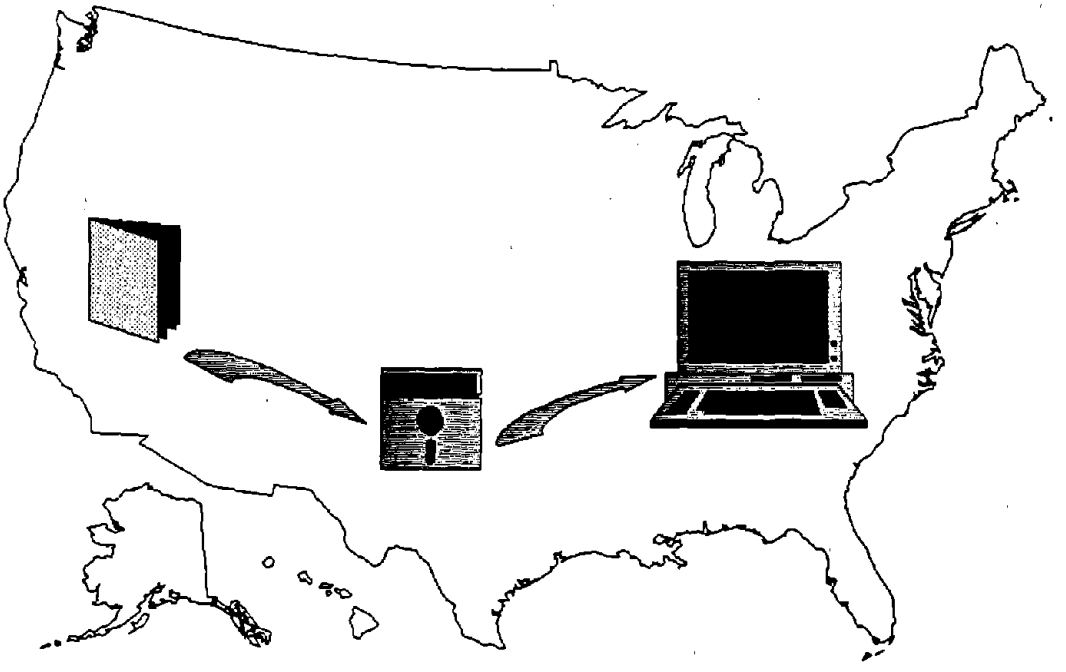
EPA

# National Radon Database

## Volume 4: State/EPA Residential Radon Survey





# NATIONAL RADON DATABASE DOCUMENTATION
## Volume 4

## The EPA/State Residential Radon Surveys: Year 4

U.S. Environmental Protection Agency
Washington, D.C. 20460

Sharon White
Work Assignment Manager

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# 1. Introduction

The National Radon Database has been developed by the U.S. Environmental Protection Agency (EPA) to distribute information collected in two recently completed radon surveys:

1. The EPA/State Residential Radon Surveys, Years 1 to 6; and
2. The National Residential Radon Survey.

The State Residential Radon Surveys were conducted in 42 states and 6 Indian lands to characterize the state-wide distribution of radon screening measurements in the lowest livable area of owner-occupied homes. The National Residential Radon Survey was designed to provide an estimate of the national frequency distribution of annual average radon concentrations in occupied residences. Data and documentation for each survey are available through the National Technical Information Service (NTIS).

## 1.1 GOALS OF THE EPA/STATE RESIDENTIAL RADON SURVEYS

> *These surveys are statistically valid at the state level and regional levels within each state. The results represent screening measurements and should not be used to estimate annual averages or health risks. Although states and portions of states have been characterized with high or low indoor radon results, the only way to determine the indoor radon level of an individual house is to test. EPA recommends that all homes test for elevated indoor radon levels.*

In response to the growing concern about potential health risks associated with indoor radon exposure, the EPA initiated a program in 1986 to assist states in measuring radon concentrations in homes. The importance of this program was confirmed by the Indoor Radon Abatement Act of 1988, Section 305, which directed the EPA to provide technical assistance to the States in assessing radon concentrations in homes. Through this program, the EPA provided assistance to states in the selection and testing of a

probability-based sample of houses. Research Triangle Institute (RTI) supported EPA and the states in this effort during the six years of surveys. Assistance was provided in survey design, interviewer training, sample selection, data processing, and data analysis. In addition, the Agency provided the charcoal canisters used in the surveys and also provided all laboratory analysis.

The goals of the state radon surveys were twofold. Some measure of the distribution of radon levels among residences was desired for major geographic areas within each state and for each state as a whole. In addition, it was desired that each state survey would be able to identify areas of potentially high residential radon concentrations ("hot spots") in the state, enabling the state to focus its attention on areas where indoor radon concentrations might pose a greater health threat.

To ensure the discovery of elevated radon concentrations within a home, the charcoal canisters were exposed under closed-house conditions during the winter and were placed on the lowest livable level. Thus, the estimates of indoor radon concentration provided by the surveys reflect a worst-case scenario and maximize the likelihood of identifying residences with high radon concentrations. The screening measurement provides a measurement of the maximum concentration to which occupants may be exposed. A screening measurement also provides a basis for determining whether additional measurements are needed for making a mitigation decision. Data from these state surveys should not, however, be used directly in assessing health risks, because the screening measurements may overstate annual average concentrations in living areas of these homes.

Since the winter of 1986-87, the EPA has assisted 42 states in conducting surveys of indoor $^{222}Rn$ concentrations. The 42 states and 6 Indian lands radon surveys included in the National Radon Database were carried out during the six years of the program as listed in Table 1-1. Probability-based surveys also were conducted in six selected Indian lands during four of the six years of the program. The use of probabilities in making

house selections allows the results to be extrapolated beyond the sample itself to a well-defined population of homes through the use of sampling weights, which are included in the database for all surveys except Colorado and Connecticut.[1] The sampling weights should be used as described in this documentation to replicate the population estimates presented here. In addition, sample data from state surveys conducted by Colorado and Connecticut are included in the Year 1 database. The sampling weights for these states are set to a value of 0 in the database.

A two-day deployment of open-faced charcoal canisters was used by 24 states and 3 Indian lands during the first three years of the state radon survey assistance program. During these years, a diffusion barrier charcoal canister was developed specifically to be less sensitive to the effects of humidity and air flow than the open-faced canister. Two-day deployment of barrier canisters was used by the eight states and two Indian lands in Year 4 of the program. The exposure period for the barrier canisters was increased from two days to seven days for Years 5 and 6. All devices were analyzed promptly at the EPA laboratory in Montgomery, Alabama. Estimates of the relative measurement error as a percentage of the measured concentration were provided by the laboratory and are included in the database. The performance of the charcoal canisters was monitored periodically through the use of unexposed canisters, canisters exposed to known levels of $^{222}Rn$, and collocated canisters.

The database now contains data on short-term screening measurements made on the lowest livable level of over 63,000 randomly selected houses during the winter heating season. Survey results for the 42 states and 6 Indian lands are listed in Table 1-2, which

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[1] Colorado and Connecticut conducted state surveys and these data are included in the database for Year 1. Because sampling weights could not be determined for these samples, the survey results for these two states should not be extrapolated beyond the sample. The States of Delaware, Florida, New Hampshire, New Jersey, New York and Utah also have conducted their own surveys. Information concerning these state surveys is included in Appendix D.

shows for each state and Indian land the number of homes tested, the estimated number of residences in the target population, population estimates of the arithmetic mean (average) screening measurement radon concentration, and the estimated population percentage of homes with screening measurements over 4 pCi/L and over 20 pCi/L. Due to the lack of sampling weights for Colorado and Connecticut, reported results are applicable only to the sample households. Results are reported separately for the six Indian lands included in the database.

The geographical distribution of estimated mean screening-level radon concentrations is depicted in Figures 1-1 and 1-2 for the 38 states in the contiguous U.S. with probability-based survey results. These states contain 225 sub-state regions. In Figure 1-1 the regions are grouped into three categories using the estimated regional mean screening measurement: 0 to 2 pCi/L; 2 to 4 pCi/L; and greater than 4 pCi/L. In Figure 1-2, the top 60 regions with an estimated mean screening level over 4 pCi/L are displayed in three more-detailed categories: 4 to 6 pCi/L; 6 to 8 pCi/L; and greater than 8 pCi/L.

Figure 1-3 shows a map of the 10 EPA regions used to define the target population for the surveys of Indian lands. The names and addresses of the EPA regional office radon contacts are included in Appendix D.

Table 1-1 Summary of Six Years of the EPA/State Residential Radon Surveys

Year 1, 1986-87 heating season: ten states

| | | | |
|---|---|---|---|
| Alabama | (AL) | Michigan | (MI) |
| Colorado | (CO) | Rhode Island | (RI) |
| Connecticut | (CT) | Tennessee | (TN) |
| Kansas | (KS) | Wisconsin | (WI) |
| Kentucky | (KY) | Wyoming | (WY) |

Year 2, 1987-88 heating season: seven states and one Indian land

| | | | |
|---|---|---|---|
| Arizona | (AZ) | Minnesota | (MN) |
| Indiana | (IN) | Missouri | (MO) |
| Massachusetts | (MA) | North Dakota | (ND) |
| Region 5 Indian Land | (R5) | Pennsylvania | (PA) |

Year 3, 1988-89 heating season: eight states and two Indian lands

| | | | |
|---|---|---|---|
| Alaska | (AK) | New Mexico | (NM) |
| Georgia | (GA) | Ohio | (OH) |
| Iowa | (IA) | Vermont | (VT) |
| Maine | (ME) | West Virginia | (WV) |
| Region 6 Indian Land | (R6) | Region 7 Indian Land | (R7) |

Year 4, 1989-90 heating season: nine states and two Indian lands

| | | | |
|---|---|---|---|
| California | (CA) | Nevada | (NV) |
| Hawaii | (HI) | North Carolina | (NC) |
| Idaho | (ID) | Oklahoma | (OK) |
| Louisiana | (LA) | South Carolina | (SC) |
| Nebraska | (NE) | Navajo Nation | (RN) |
| Billings, MT IHS Area | (RB) | | |

Year 5, 1990-91 heating season: six states and one Indian land

| | | | |
|---|---|---|---|
| Arkansas | (AR) | Mississippi | (MS) |
| Illinois | (IL) | Texas | (TX) |
| Maryland | (MD) | Washington | (WA) |
| Eastern Cherokee Nation | (RC) | | |

Year 6, 1991-92 heating season: two states

| | | | |
|---|---|---|---|
| Montana | (MT) | Virginia | (VA) |

Table 1-2 EPA/State Residential Radon Survey Results, Years 1 to 6

| State/Indian Land | # Homes Tested | Estimated # Homes in Population | Screening-Level Estimates: Arithmetic Mean | Percent > 4 pCi/L | Percent > 20 pCi/L |
|---|---|---|---|---|---|
| AK | 1,127 | 38,287 | 1.7 | 7.7 | 0.6 |
| AL | 1,180 | 565,603 | 1.8 | 6.4 | 0.3 |
| AR | 1,535 | 411,395 | 1.2 | 5.0 | 0.3 |
| AZ | 1,507 | 481,861 | 1.6 | 6.5 | 0.1 |
| CA | 1,885 | 2,232,780 | 1.0 | 2.4 | 0.1 |
| CO* | 1,443 | 1,443 | 5.2 | 41.5 | 2.7 |
| CT* | 1,451 | 1,451 | 2.8 | 18.5 | 0.9 |
| GA | 1,534 | 826,452 | 1.8 | 7.5 | 0.0 |
| HI | 523 | 67,044 | 0.2 | 0.4 | 0.0 |
| IA | 1,381 | 593,815 | 8.9 | 71.0 | 7.5 |
| ID | 1,266 | 187,124 | 3.3 | 20.3 | 1.1 |
| IL | 1,450 | 1,537,325 | 2.9 | 19.2 | 0.8 |
| IN | 1,914 | 992,634 | 3.7 | 28.5 | 1.5 |
| KS | 2,009 | 509,496 | 3.1 | 22.5 | 0.7 |
| KY | 879 | 585,655 | 2.7 | 17.1 | 1.5 |
| LA | 1,314 | 432,162 | 0.5 | 0.8 | 0.0 |
| MA | 1,659 | 1,010,301 | 3.4 | 22.7 | 1.3 |
| MD | 1,126 | 761,456 | 3.1 | 18.9 | 1.4 |
| ME | 839 | 236,917 | 4.1 | 29.9 | 1.9 |
| MI | 1,989 | 1,519,962 | 2.1 | 11.7 | 0.4 |
| MN | 919 | 966,496 | 4.8 | 45.4 | 1.4 |
| MO | 1,859 | 998,706 | 2.6 | 17.0 | 0.7 |
| MS | 960 | 352,285 | 0.9 | 2.2 | 0.1 |
| MT | 833 | 151,605 | 6.0 | 42.2 | 4.7 |
| NC | 1,290 | 1,114,747 | 1.4 | 6.7 | 0.3 |
| ND | 1,596 | 194,315 | 7.0 | 60.7 | 4.3 |
| NE | 2,027 | 310,857 | 5.5 | 53.5 | 1.9 |
| NM | 1,885 | 191,090 | 3.2 | 21.8 | 0.8 |
| NV | 1,562 | 93,004 | 2.0 | 10.2 | 0.8 |
| OH | 1,734 | 1,843,743 | 4.3 | 29.0 | 2.8 |
| OK | 1,637 | 538,309 | 1.1 | 3.3 | 0.0 |
| PA | 2,389 | 2,262,234 | 7.7 | 40.5 | 7.9 |
| RI | 376 | 165,646 | 3.2 | 20.6 | 1.9 |
| SC | 1,089 | 505,281 | 1.1 | 3.7 | 0.3 |
| TN | 1,773 | 741,551 | 2.7 | 15.8 | 1.3 |
| TX | 2,680 | 2,216,326 | 1.0 | 3.6 | 0.2 |
| VA | 1,156 | 972,708 | 2.3 | 13.9 | 1.2 |
| VT | 710 | 117,523 | 2.5 | 15.9 | 0.9 |
| WA | 1,935 | 711,965 | 1.7 | 8.8 | 1.3 |
| WI | 1,191 | 933,700 | 3.4 | 26.6 | 0.8 |
| WV | 1,006 | 324,038 | 2.6 | 15.7 | 0.8 |
| WY | 777 | 74,234 | 3.6 | 26.2 | 1.8 |
| SUBTOTAL | 59,395 | 28,773,526 | | | |
| R5 | 934 | 5,328 | 2.9 | 19.7 | 1.3 |
| R6 | 740 | 5,443 | 2.7 | 16.9 | 0.8 |
| R7 | 669 | 8,478 | 5.4 | 34.9 | 2.7 |
| RB | 187 | 5,834 | 2.9 | 22.3 | 0.0 |
| RC | 594 | 786 | 0.8 | 1.7 | 0.0 |
| RN | 772 | 33,354 | 1.7 | 8.3 | 0.0 |
| SUBTOTAL | 3,896 | 59,223 | | | |
| TOTAL | 63,291 | | | | |

(*) - Colorado and Connecticut results apply only to those homes tested in the survey.

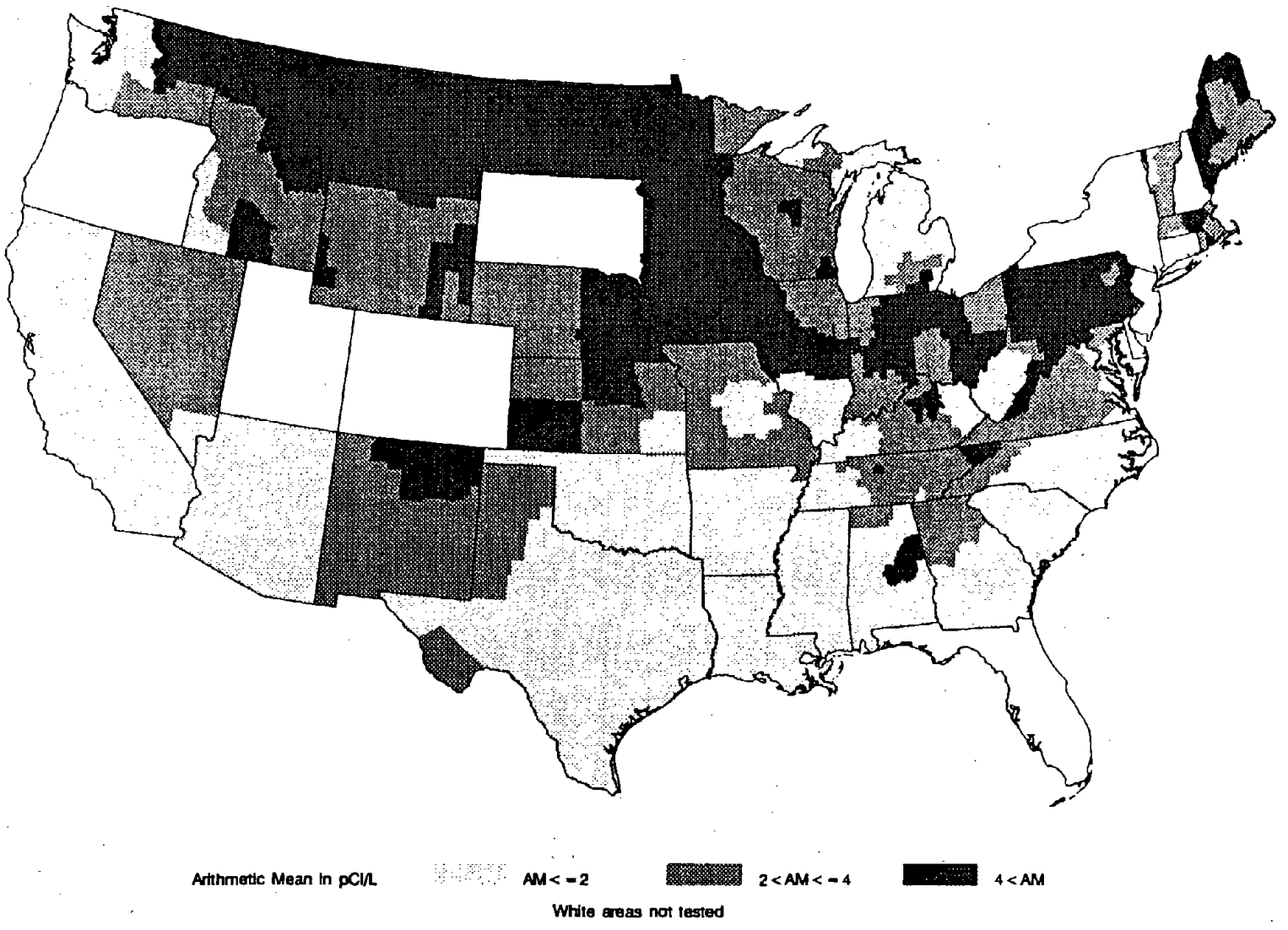


Figure 1. Distribution of Arithmetic Means of Screening Measurements in 225 Regions

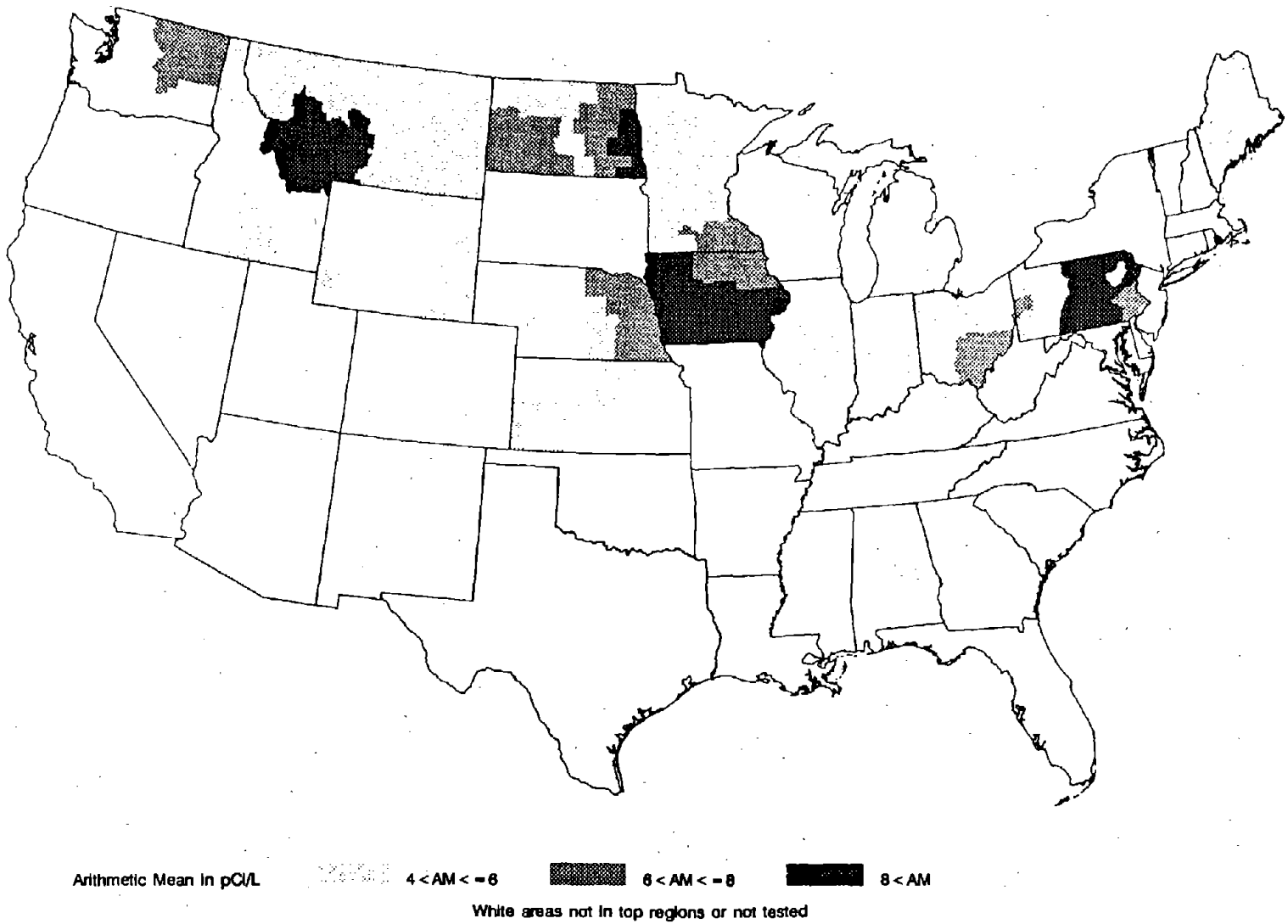


Figure 2. Distribution of Arithmetic Means of Screening Measurements in the Top 60 Regions

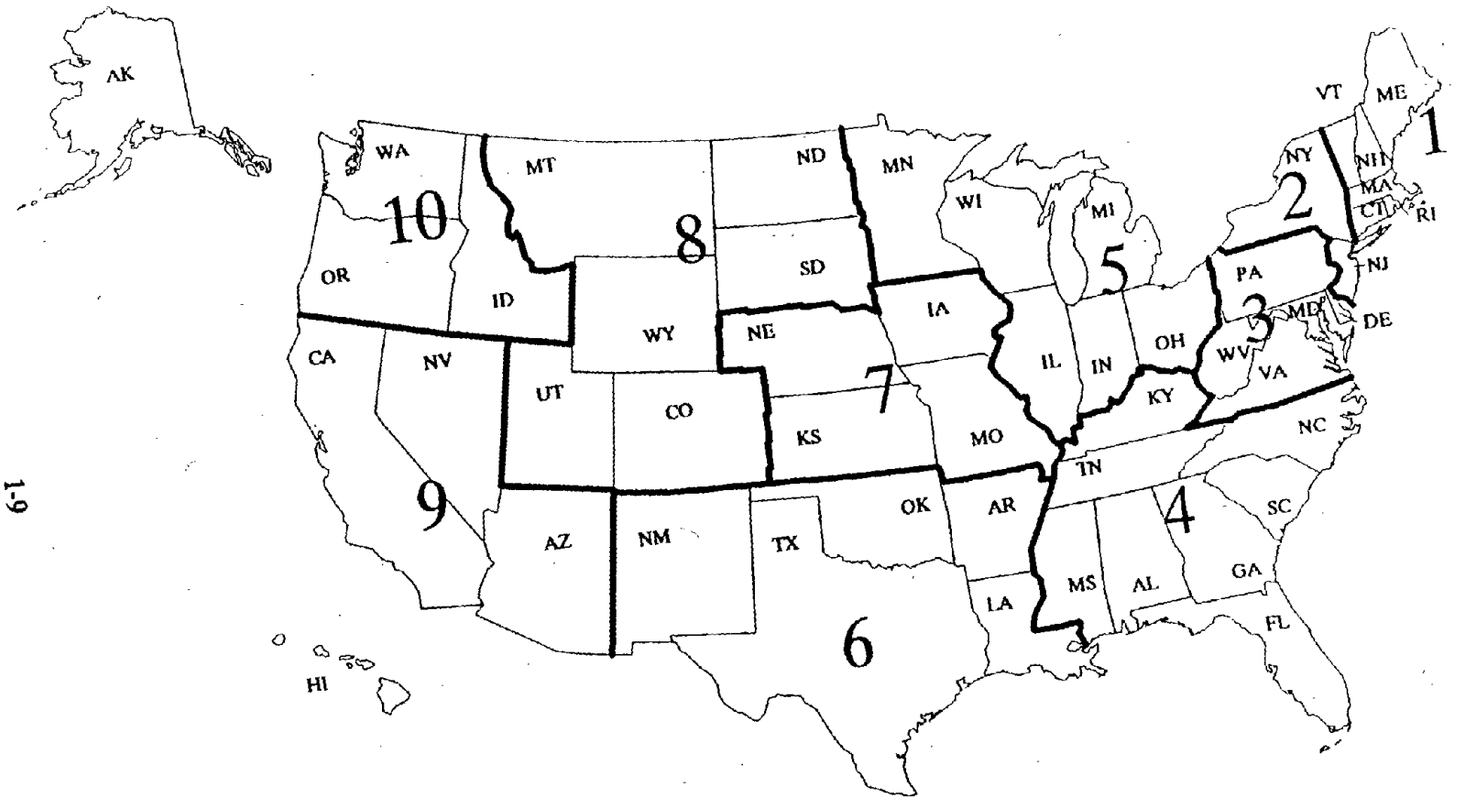


Figure 3. EPA Regions

## 1.2 SUMMARY OF THE YEAR 4 SURVEYS

During the winter and spring of 1989-1990, EPA assisted 9 states and 2 Indian nations in conducting state radon surveys, measuring radon concentrations in several thousand residences. The following states and Indian nations participated with EPA in carrying out statewide radon surveys in Year 4:

| | | | |
|---|---|---|---|
| California | (CA) | The Navajo Nation, with | (RN) |
| Hawaii | (HI) | lands in Utah, Colorado, | |
| Idaho | (ID) | Arizona, and New Mexico | |
| Louisiana | (LA) | | |
| Nebraska | (NE) | | |
| Nevada | (NV) | | |
| North Carolina | (NC) | Indian lands in Montana | (RB) |
| Oklahoma | (OK) | and Wyoming | |
| South Carolina | (SC) | | |

Three different types of samples were used for the eleven Year 4 surveys. For each of the nine states conducting surveys during Year 4, a random sample of residences with directory-listed telephone numbers was selected. For Indian lands surveys, however, the samples were selected without regard to the existence of a listed telephone number. Using a listing of all residences located on seven Indian reservations in Montana and one Indian reservation in Wyoming, a probability sample of residences was selected for the survey of Indian lands in Montana and Wyoming. An area probability sample of housing units was selected for the Navajo survey.

The state radon screening survey results are statistically valid at the state and sub-state regional level. The assignment of counties to regions within each state is detailed in Table C-1 of Appendix C. The number of radon detectors (charcoal canisters) also is shown for each county in this table. Table 1-3 contains population estimates for selected parameters of the regional and state-wide radon distribution. These estimates were obtained using the appropriate sampling weights, as described in Section 3.3. The table

contains estimates of the mean (average) screening measurement, the median, the geometric mean, the 75th and 90th percentiles, and the percent of houses over 4 pCi/L and over 20 pCi/L.

Table 1-3 Parameter Estimates from the Distribution of Indoor Radon Screening Measurements in Year 4 Surveys, by State and Region (1989-90)

| | Number Houses Tested | Est. No. Houses in Population | Arith. Mean pCi/L | Geo. Mean pCi/L | Median pCi/L | 75th Percentile pCi/L | 90th Percentile pCi/L | % Houses > 4 pCi/L | % Houses > 20 pCi/L |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | California | | | | |
| State | 1,885 | 2,232,780 | 0.9 | 0.5 | 0.7 | 1.2 | 2.1 | 2.4 | 0.1 |
| Region 1 | 201 | 85,432 | 0.6 | 0.3 | 0.3 | 0.9 | 1.3 | 2.1 | 0.0 |
| Region 2 | 135 | 38,566 | 1.0 | 0.5 | 0.7 | 1.3 | 2.1 | 3.7 | 0.0 |
| Region 3 | 230 | 97,911 | 1.1 | 0.4 | 0.6 | 1.3 | 2.5 | 4.7 | 0.4 |
| Region 4 | 175 | 262,045 | 1.3 | 0.6 | 0.9 | 1.4 | 2.7 | 3.6 | 0.0 |
| Region 5 | 185 | 54,049 | 1.1 | 0.5 | 0.7 | 1.6 | 2.8 | 3.7 | 0.0 |
| Region 6 | 242 | 366,348 | 1.1 | 0.5 | 0.6 | 1.3 | 2.5 | 5.5 | 0.5 |
| Region 7 | 305 | 130,066 | 1.5 | 1.0 | 1.2 | 2.1 | 2.8 | 3.0 | 0.3 |
| Region 8 | 230 | 98,164 | 1.3 | 0.7 | 0.9 | 1.5 | 2.8 | 5.2 | 0.0 |
| Region 9 | 182 | 1,100,199 | 0.6 | 0.4 | 0.6 | 1.0 | 1.6 | 0.5 | 0.0 |
| | | | | | Hawaii | | | | |
| State | 523 | 67,044 | 0.1 | 0.1 | 0.0 | 0.3 | 0.6 | 0.4 | 0.0 |
| Region 1 | 138 | 7,912 | 0.0 | 0.1 | 0.0 | 0.2 | 0.5 | 0.8 | 0.0 |
| Region 2 | 79 | 7,446 | 0.1 | 0.1 | 0.0 | 0.3 | 0.7 | 0.0 | 0.0 |
| Region 3 | 49 | 3,072 | 0.2 | 0.2 | 0.2 | 0.4 | 0.6 | 0.0 | 0.0 |
| Region 4 | 257 | 48,614 | 0.1 | 0.1 | 0.0 | 0.3 | 0.6 | 0.4 | 0.0 |
| | | | | | Idaho | | | | |
| State | 1,266 | 187,124 | 3.3 | 1.6 | 1.8 | 3.6 | 7.4 | 20.3 | 1.2 |
| Region 1 | 66 | 23,851 | 5.1 | 1.7 | 1.9 | 5.8 | 16.6 | 30.5 | 2.7 |
| Region 2 | 133 | 14,797 | 2.2 | 0.9 | 1.1 | 2.5 | 4.7 | 15.8 | 0.8 |
| Region 3 | 57 | 18,734 | 2.0 | 1.2 | 1.2 | 1.9 | 3.8 | 8.9 | 0.0 |
| Region 4 | 774 | 40,172 | 2.6 | 1.7 | 1.9 | 3.2 | 5.0 | 16.4 | 0.4 |
| Region 5 | 70 | 24,318 | 4.1 | 1.6 | 1.6 | 3.8 | 7.2 | 22.9 | 3.8 |
| Region 6 | 80 | 33,683 | 3.2 | 1.9 | 2.0 | 3.8 | 7.8 | 21.9 | 0.0 |
| Region 7 | 86 | 31,571 | 3.5 | 1.7 | 2.1 | 3.5 | 10.5 | 22.6 | 1.0 |
| | | | | | Louisiana | | | | |
| State | 1,314 | 432,162 | 0.5 | 0.3 | 0.4 | 0.7 | 1.2 | 0.8 | 0.0 |
| Region 1 | 449 | 147,769 | 0.6 | 0.3 | 0.4 | 0.8 | 1.4 | 1.6 | 0.0 |
| Region 2 | 251 | 73,543 | 0.4 | 0.3 | 0.3 | 0.7 | 1.2 | 0.8 | 0.0 |
| Region 3 | 348 | 101,905 | 0.4 | 0.3 | 0.4 | 0.7 | 1.0 | 0.6 | 0.0 |
| Region 4 | 266 | 108,944 | 0.3 | 0.2 | 0.3 | 0.6 | 0.8 | 0.0 | 0.0 |
| | | | | | Nebraska | | | | |
| State | 2,027 | 310,857 | 5.5 | 3.9 | 4.3 | 7.0 | 10.2 | 53.5 | 1.9 |
| Region 1 | 414 | 186,525 | 6.1 | 4.8 | 5.0 | 7.7 | 10.4 | 62.9 | 2.4 |
| Region 2 | 358 | 32,902 | 7.1 | 4.4 | 5.2 | 9.4 | 15.2 | 57.9 | 4.2 |
| Region 3 | 390 | 29,050 | 3.0 | 2.2 | 2.5 | 4.1 | 5.8 | 25.5 | 0.0 |
| Region 4 | 402 | 20,892 | 3.4 | 2.5 | 2.6 | 4.2 | 6.6 | 26.6 | 0.0 |
| Region 5 | 463 | 41,487 | 4.2 | 3.0 | 3.4 | 5.4 | 8.1 | 40.8 | 0.4 |

Table 1-3 Parameter Estimates from the Distribution of Indoor Radon Screening Measurements in Year 4 Surveys, by State and Region (1989-90) (Continued)

| | Number Houses Tested | Est. No. Houses in Population | Arith. Mean pCi/L | Geo. Mean pCi/L | Median pCi/L | 75th Percentile pCi/L | 90th Percentile pCi/L | % Houses > 4 pCi/L | % Houses > 20 pCi/L |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Nevada | | | | |
| State | 1,562 | 93,004 | 2.0 | 1.0 | 1.1 | 2.1 | 4.1 | 10.2 | 0.8 |
| Region 1 | 188 | 45,559 | 1.1 | 0.6 | 0.8 | 1.4 | 2.2 | 3.8 | 0.0 |
| Region 2 | 288 | 4,605 | 2.8 | 1.5 | 1.6 | 3.2 | 5.6 | 17.2 | 1.0 |
| Region 3 | 172 | 11,020 | 3.1 | 1.9 | 2.2 | 3.7 | 5.9 | 19.4 | 0.6 |
| Region 4 | 154 | 21,220 | 2.7 | 1.2 | 1.3 | 2.2 | 5.4 | 15.2 | 2.6 |
| Region 5 | 156 | 3,298 | 2.5 | 1.4 | 1.5 | 2.6 | 3.7 | 9.8 | 2.0 |
| Region 6 | 215 | 1,748 | 3.2 | 2.0 | 2.2 | 4.0 | 6.8 | 24.7 | 0.9 |
| Region 7 | 185 | 3,905 | 2.7 | 1.6 | 1.7 | 3.3 | 5.8 | 16.4 | 0.0 |
| Region 8 | 204 | 1,649 | 2.3 | 1.3 | 1.3 | 2.4 | 4.2 | 11.6 | 1.0 |
| | | | | | North Carolina | | | | |
| State | 1,290 | 1,114,747 | 1.4 | 0.6 | 0.6 | 1.4 | 3.3 | 6.7 | 0.3 |
| Region 1 | 147 | 239,175 | 0.4 | 0.2 | 0.3 | 0.6 | 1.0 | 0.6 | 0.0 |
| Region 2 | 158 | 260,095 | 0.9 | 0.4 | 0.6 | 1.1 | 1.8 | 4.6 | 0.0 |
| Region 3 | 194 | 317,400 | 1.3 | 0.6 | 0.7 | 1.5 | 3.1 | 6.3 | 0.5 |
| Region 4 | 351 | 133,818 | 2.0 | 0.9 | 1.1 | 2.0 | 3.8 | 8.9 | 0.3 |
| Region 5 | 440 | 164,259 | 3.4 | 1.5 | 1.7 | 3.5 | 5.7 | 17.9 | 0.7 |
| | | | | | Oklahoma | | | | |
| State | 1,637 | 538,309 | 1.1 | 0.5 | 0.7 | 1.4 | 2.5 | 3.3 | 0.0 |
| Region 1 | 238 | 109,228 | 1.2 | 0.6 | 0.8 | 1.4 | 2.4 | 3.4 | 0.0 |
| Region 2 | 211 | 52,609 | 1.4 | 0.5 | 0.6 | 1.2 | 3.1 | 6.4 | 0.0 |
| Region 3 | 276 | 63,909 | 0.6 | 0.3 | 0.4 | 1.0 | 1.6 | 1.1 | 0.0 |
| Region 4 | 205 | 51,852 | 0.8 | 0.4 | 0.5 | 1.1 | 1.6 | 2.4 | 0.5 |
| Region 5 | 213 | 141,316 | 1.0 | 0.5 | 0.7 | 1.3 | 2.4 | 1.5 | 0.0 |
| Region 6 | 266 | 64,341 | 1.3 | 0.7 | 0.9 | 1.6 | 2.8 | 3.8 | 0.0 |
| Region 7 | 228 | 55,053 | 1.6 | 1.0 | 1.1 | 2.1 | 3.5 | 7.5 | 0.0 |
| | | | | | South Carolina | | | | |
| State | 1,089 | 505,281 | 1.1 | 0.5 | 0.6 | 1.2 | 2.2 | 3.7 | 0.3 |
| Region 1 | 548 | 254,462 | 1.5 | 0.7 | 0.9 | 1.6 | 3.1 | 7.0 | 0.4 |
| Region 2 | 145 | 67,150 | 0.7 | 0.4 | 0.6 | 1.1 | 1.6 | 0.0 | 0.0 |
| Region 3 | 100 | 46,306 | 0.5 | 0.3 | 0.2 | 0.9 | 1.6 | 0.0 | 0.0 |
| Region 4 | 296 | 137,363 | 0.7 | 0.3 | 0.4 | 0.9 | 1.4 | 0.7 | 0.3 |
| | | | | | Billings, MT IHS Area | | | | |
| All | 187 | 5,834 | 2.9 | 1.7 | 2.0 | 3.8 | 5.8 | 22.3 | 0.0 |
| Region 1 | 17 | 3,054 | 3.3 | 1.8 | 1.3 | 3.4 | 5.0 | 23.5 | 0.0 |
| Region 2 | 27 | 1,337 | 2.5 | 1.5 | 2.0 | 3.4 | 5.2 | 22.2 | 0.0 |
| Region 3 | 98 | 1,028 | 2.9 | 1.9 | 1.8 | 3.6 | 5.5 | 23.1 | 0.0 |
| Region 4 | 45 | 416 | 1.8 | 1.1 | 1.3 | 2.0 | 3.5 | 11.1 | 0.0 |
| | | | | | Navaho Nation | | | | |
| All | 772 | 33,354 | 1.7 | 0.9 | 1.1 | 2.0 | 3.6 | 8.3 | 0.0 |

# 2. The Sample Design

## 2.1 THE OVERALL SAMPLING PLAN

The sampling plan for the state radon surveys called for the selection of probability samples of residences in each state. A probability sample is one in which every element in the population has a known positive chance of selection. Probability sampling permits the extrapolation of survey results to the entire population and, in addition, permits the calculation of measures of precision for the estimates. Because one of the goals of each state radon survey was the generation of estimates of distributions of residential radon levels for the state as a whole and for the major geographic areas within the state, use of probability sampling was imperative. Probability-based surveys were also necessary to validly compare results from one state with results from other.

## 2.2 POPULATION DEFINITION AND SAMPLING FRAMES

The target population for the surveys in nine of Year 4 states consisted of owner-occupied homes with permanent foundations and at least one floor at or below ground level and with a telephone number published in the latest directory. (Mobile homes with permanent foundations and airtight panels/skirts and with a published telephone number were also included.) The statistical estimates generated from the survey data apply to this population.

In reality, the totality of occupied residences in the state constituted the population of interest. However, as is often the case in survey research, it was not feasible to survey this population, for several reasons. First, it was considered inadvisable from a legal perspective to include rental dwellings without first obtaining the permission of the owner. While procedures could be devised to obtain such permission, the cost in doing so both in dollars and in delay in the survey schedule was deemed impractical. Second, homes that had no floor on or below ground level were excluded from the survey target

population. Although these homes are usually rental apartment units, the category would include some owner-occupied condominiums. These were excluded from the target population because radon levels on upper floors were expected to be low, and it was felt that the focus of the survey should be on residences that were potentially at risk. Third, the survey target population was restricted to homes with listed telephone numbers, basically because of time and cost considerations. Sampling of homes without regard to the existence a telephone would call for an area probability procedure, which required on-site staff for both listing and data collection and is both expensive and time consuming. The telephone survey approach was used because it offered a more economically feasible alternative. Telephone surveys can be implemented using a relatively small staff working in a central location, and can be carried out on short notice and within a restricted time schedule.

Two types of samples are commonly used for telephone surveys, random digit dialing samples, for which every possible telephone number is given a positive chance of being selected into the sample, and telephone directory samples, for which only listed telephone numbers are given a chance of selection. All Year 4 state radon surveys used samples selected from directory-based files.

## 2.3 STRATIFICATION AND SAMPLE ALLOCATION

To improve the precision of the survey estimates and to ensure an adequate sample size in each of the reporting regions, the sampling frame for each of the nine states was stratified by reporting region prior to sample selection. Because different sampling rates were used for different strata, it was possible to control the size of the sample selected from each reporting region. Two or more alternative sampling allocations were produced and provided to each state. The first allocation was based on equal probability sampling, which yielded samples that were distributed across strata in the same way the population was distributed. One of the disadvantages of equal probability sampling was that it could result in small sample sizes for small reporting groups.

The second alternative allocation that was provided avoided this potential problem by allocating the sample equally to the different strata. However, to achieve an equal allocation when the strata vary in size, different sampling rates were used for the different strata. The unequal sampling weights, which must be used in the estimation process in order to account for the differing sampling rates, can have the effect of lowering the precision of the statewide estimates.

There were obvious tradeoffs among the different allocation alternative. For each allocation provided to a state, a table showing the expected precision for statewide and reporting group estimates was provided. This enabled the state to view the tradeoffs in precision associated with the different types of allocations.

States were typically interested in the number of homes that would be tested in each of the counties of the state. For each of the sample allocations, a distribution showing the expected sample size for each county was produced using the Market Statistics' estimate of the number of occupied housing units in each county in 1989.

Each Year 4 state was provided with descriptive information about the proportional allocation, based on equal probability sampling, and the equal allocation. The information provided consisted of tables showing the expected precision of the survey estimates and the expected distribution of the sample, described above, as well as a discussion of the advantages and disadvantages of each allocation. The state representatives were therefore able to consider two sample designs prior to participating in the detailed survey planning sessions that were carried out for each state survey. Tables for additional allocations were prepared when appropriate so that the state could see the effect of increasing or decreasing the overall size of the sample, the effect of sampling more heavily in sparsely settled areas, or the effect of sampling more heavily in areas that were suspected of having elevated residential radon levels.

After considering all of the allocation options provided, the state, with EPA's approval, decided on one of the allocations.

A description of the allocation that was chosen by the state, the target number of canisters to be placed, the sampling rates used in each of the strata, and the expected design effect (DEFF) due to unequal weighting for variables that are uniformly distributed across strata is presented for each state in Appendix C.

Following guidelines determined by the selected allocation, the samples for the nine states were selected from the Donnelley Marketing files. In all cases, detailed instructions for ordering the file and selecting the sample for each state were prepared. The instructions called for ordering the residential telephone listings in each stratum by the size rank of the county in which the residence was located, then by the census block group or enumeration district. The listings were finally ordered by telephone number. This ensured maximum geographic spread when systematic random sample selection procedures were used.

## 2.4 SAMPLE SELECTION PROCEDURES

To permit the unbiased estimation of the sampling errors of the survey estimates of radon characteristics for the state and for major geographic subparts of the state, five independent systematic random samples were selected from each stratum. To do this, RTI provided the sample size to be selected from each stratum for each of the five samples, a list of the counties that made up each stratum, and the specifications for ordering the file within each stratum. The sample selection instructions that were provided are presented in Table 2-1.

The following variables were requested for each sample selection:

1. State FIPS code,
2. County FIPS code,
3. Stratum,
4. Area code,
5. Telephone number,
6. Name,
7. Mailing address,
8. Zip code, and
9. Sample (or replicate) number (1-5).

In addition to the tape, a printout was requested for the state showing, for each stratum, the values for L, S, and I, as defined in Table 2-1.

Table 2-1 Procedures for Selecting the Sample of Telephone Numbers

1. Sort all residential telephone numbers in the state as specified.
2. Determine the number of listings of residential telephone numbers on the file for the stratum. Call this number L.
3. Identify the sample size specified for the stratum and call this number S.
4. Divide L by S to obtain the Selection Interval I.
5. Select 5 different random numbers between (and including) 0.00000001 and I.
6. Successively add I to the first random number to generate S selection numbers. Round up the S selection numbers for the stratum to identify the sample telephone numbers on the ordered list.
7. Repeat step 6 for each of the other 4 random numbers until all 5 random samples of size S have been selected.
8. When this procedure has been implemented for all strata defined for a state, the state's sample selection is complete.

## 2.5 PARTITIONING THE SAMPLES INTO WAVES

Estimating the exact number of sample selections that would be needed in a state survey to be able to place the desired number of canisters was very difficult. EPA did not know the exact proportion of selected numbers that would be working residential numbers, the exact proportion of residential numbers that would be associated with survey-eligible residences, or the proportion of eligible residences that would participate in the study. Another very important unknown was when the weather in the state would become so warm that the closed house requirement for canister deployment could not be met, and the survey would have to be discontinued.

There is a commonly used technique for controlling the number of survey participants in situations where there are many unknowns involved in estimating the number of sample selections needed. The procedure involves partitioning the sample into a number of random subsamples and implementing only as many of the subsamples as are needed to achieve the desired number of participants. This technique was used in all nine states.

A sample sufficiently large for any reasonable set of assumptions was selected as described above. It was then partitioned into random subsamples, or waves, of 50 telephone listings each. The waves were randomly ordered and numbered sequentially, and were activated in numerical order by the states. Because each sample wave was a random miniature version of the entire sample, no matter where a state stopped they would have implemented a random sample of listed residential telephone numbers, provided only that they had completed all waves that were begun.

The procedures used in processing the file and partitioning the sample into waves are described below.

1. The sample of 10-digit telephone numbers was checked for duplicates, which were eliminated, and was checked to verify that the proper number of records had been provided for each replicate in each stratum.

2. The total number of waves, W, into which the sample was to be partitioned was determined by dividing the number of records on the file by 50.

3. The waves number 1 through W were put in random order and assigned to the first W records of the file. The wave numbers 1 through W were again placed in a random order and assigned to the second W records on the file, etc., until each record had been assigned a Wave number.

4. The records were ordered by wave number and a Case ID number was assigned sequentially.

A slight modification of these procedures was used to partition the samples for the two Indian lands surveys into waves.

Note that in Year 4 duplicate canisters were not placed in a random subsample of homes. This procedure had been discontinued the previous year because participants in Year 1 and 2 had not consistently exposed duplicate canisters in the same room at the same time. Duplicate measurements in Year 3 and 4 were made in the homes of interviewers and in chamber exposures.

## 2.6 THE INDIAN LANDS SURVEYS

The IHS carried out two residential radon surveys on Indian lands during Year 4. One survey covered Indian lands in Montana and Wyoming, and the other covered the Navajo Nation, which included land in Utah, Colorado, Arizona and New Mexico. For both Indian lands surveys, personal interviews, rather than telephone interviews, were obtained, and canisters were placed and retrieved by the same interviewers.

The target populations for the two Year 4 Indian lands surveys were wider in scope than those covered in the state surveys. All occupied homes with at least one floor on or below ground level and located on one of the designated Indian lands survey locations were survey eligible. Survey eligibility criteria for the Year 4 Indian surveys therefore permitted the inclusion of homes located on federally owned land, homes that were rented, and homes without a telephone. However, because each respondent was asked about home ownership and the presence of a telephone for private use in the home, each Indian lands sample can be partitioned into two groups: those cases that met the stricter eligibility criteria used in the state surveys and those cases that did not. This partitioning permitted a state to include homes on Indian lands in state level estimates if the state desired to do so.

## 2.7 THE MONTANA-WYOMING INDIANS SURVEY

Eight Indian reservations were included in this survey. One reservation, Wind River, was located in Wyoming, and seven are located in Montana. The Montana reservations are 1) Black Feet, 2) Flat Head, 3) Rocky Boy, 4) Ft. Belknap, 5) Ft. Peck, 6) Northern Cheyenne, and 7) Crow.

The sampling frame, which was constructed by the Billings Area Indian Health Service (BAIHS), consisted of a list of serial numbers, each of which corresponded to a privately owned home in one of the reservations listed above. A random sequential sample of serial numbers from each reservation was selected and the file provided to the BAIHS. The BAIHS identified the address associated with each selected serial number, thus identifying the sample homes to be included in the survey. As with the State surveys, the sample was randomly partitioned in to sample waves of 50 selections each.

## 2.8 THE NAVAJO NATION SURVEY

Because there was no listing of homes located on the Navajo reservation and because creating such a list would have been extremely expensive, an area probability sample of homes was used.

Data files from the 1980 Census were used to create a sampling frame that listed the Census enumeration district (EDs) together with the number of occupied housing units, the number of Indians, and the number of non-Indians in each ED on the Navajo reservation. The estimated number of survey eligible homes was then calculated for each ED by multiplying the number of occupied housing units in the ED by its ratio of Indian to total population. A measure of size equal to 0.1 times the estimated number of survey eligible housing units was assigned to each ED. EDs with zero estimated eligible homes were assigned one measure of size and placed in a second stratum.

Using a random sequential selection procedure 150 selections were made from stratum 1 with probabilities proportional to the measures of size, and ten selections were made from stratum 2 with equal probability. If a selected ED had been assigned more than one measure of size, it was partitioned in the field and one of its subparts was selected. This procedure produced an approximately equal probability sample of compact geographical areas, called segments, with an expected ten survey eligible homes per sample segment. The sample was randomly partitioned into 10 sample waves, each wave consisting of 15 selections from stratum 1 and 1 selection from stratum 2.

# 3. Estimation Using Survey Results

## 3.1 CALCULATION OF SAMPLING WEIGHTS

Because most of the states used unequal probability sample designs for their state radon surveys, sampling weights that counter-balance the unequal probabilities of selection must be used in order to generate unbiased state-wide population estimates from the survey data. Sampling weights that reflect only the differential selection probabilities would be adequate if 100 percent response rates and participation rates were achieved. However, this level of response was not obtained. For the state radon surveys, some of the sample cases failed to complete a screening interview, either because they were never successfully contacted or because they refused to provide the screening information. Whether or not they were in fact eligible was, therefore, never determined. For other cases the screening information was provided, and the housing unit was determined to be eligible for the survey, but a canister reading was not successfully linked to the case. There are numerous reasons why this might have occurred.

The canister may not have been read, because it was never deployed; it may have been deployed but never returned; or it may have been returned but not received in time to be included in the analysis. In addition, clerical or keying errors associated with matching criteria could have prevented matching canister readings with the proper cases. In order to compensate for the missing information, a weighting class adjustment was used. This procedure increased the sampling weights of participants to compensate for the missing information from nonparticipants. The steps used in calculating sampling weights and adjustments for the nine Year 4 states are described below.

The first step in calculating the sampling weight was determined from the information provided by Donnelley Market Services. For each stratum in the sample, we were provided with the number of listings from which the sample was selected. RTI had specified the number of selections that should be made. Using this information the first

component of the sampling weight was computed for each stratum, and used for all selections from that stratum. For any stratum h the first sampling weight component was calculated as

$$W'_h = N_h / [(5)(n_h)], \quad (1)$$

because 5 samples of size $n_h$ were selected from $N_h$ listings in stratum h.

As was described in Chapter 2, each state's sample was randomly partitioned into waves of 50 listings each, each wave being in effect a probability sample of the entire sample. Although all waves were available for use in the state radon survey, not all were used. The second component of the sampling weight represented the portion of the sample waves that were included in the analysis. Any wave for which at least 45 of the 50 cases were completed was considered to have been implemented, and was referred to as an "active" wave. Computer runs were made on the Control/Screening form file to determine which waves would be classified as "active" and included in the analysis and which would not. For each state, we then computed the sampling weight component reflecting the proportion of wave classified as active. This was merely the total number of waves of 50 listings divided by the number of waves classified as active waves, or V/v. Only cases in the v active waves were used in the remaining calculations and in the analysis.

Next an unadjusted sampling weight was calculated for every selected case in every active wave, regardless of the response or participation status of the case. This weight was merely the product of the two weight components.

$$W''_h = (W'_h)(V/v) \quad (2)$$

Next, every record in every active wave was compared to the file of canister readings and, by matching on House ID number, was classified as a participant or a nonparticipant. All active wave cases classed as participants would be used in the

analysis, because they were in an active wave and had a canister reading. To adjust for missing canister readings for the remaining survey eligibles that did not participate, all active wave nonparticipant cases were further classified according to eligibility status. The following groups were formed for the active wave cases:

Group A: Participants (all eligible cases for which a canister reading was available)

Group B: Survey eligible nonparticipants

Group C: Nonparticipants, survey eligibility unknown. (All cases for which eligibility information was never obtained.)

Group D: Nonparticipants known to be ineligible for the survey.

These four groupings were used in calculating the adjustments for nonresponse.

Five weighting classes were formed within each stratum, each being one of the five replicates used in the sample selection. Within each weighting class an adjustment-for-nonresponse factor was computed in two steps as follows:

First, an estimate of the proportion of cases that were survey eligible was computed.

$$A'_{sh} = \frac{|\Sigma\ W''_{shi}\ |_A + |\Sigma\ W''_{shi}\ |_B}{|\Sigma\ W''_{shi}\ |_A + |\Sigma\ W''_{shi}\ |_B + |\Sigma\ W''_{shi}\ |_D} \qquad (3)$$

where

$|\Sigma\ W''_{shi}\ |_A$ is the sum of the unadjusted sampling weights over all participants i in the s replica in stratum h, and where subscripts B and D refer to survey eligible nonparticipants and nonparticipants known to be ineligible, respectively.

The proportion $A'_{sh}$ was used to estimate the proportion eligible among those for whom eligibility has not been determined. This figure was needed in order to determine the nonresponse adjustment factor for each replica s within each stratum h:

$$A'_{shi} = \frac{|\Sigma\ W''_{shi}|_A + |\Sigma\ W''_{shi}|_B + A'_{sh}\ |\Sigma\ W''_{shi}|_C}{|\Sigma\ W''_{shi}|_A} \qquad (4)$$

where $|\Sigma\ W''_{shi}|_C$ is the sum of the unadjusted weights over all nonparticipants with unknown eligibility and where all other terms are as defined above.

The final sampling weight was then calculated for each sample case in every active wave as:

$$W_{shi} = (W''_{shi})(A'_{shi}), \qquad (5)$$

and the sampling weight $W_{shi}$ was used as the sampling weight in all analysis. The sampling weights calculated by the procedure above are included in the Year 4 data file. In the following section, instructions for use of the weights are given.

## 3.2 ESTIMATING MEANS AND PROPORTIONS

The analytical results calculated from the survey radon measurements should reflect the sampling weights define in the previous section. Computer software was developed by Research Triangle Institute for analyzing the data collected in this complex multistage sample survey. Formulas used in the software for estimating means and proportions are shown below.

Define $Y^*_r$ as the true mean radon level for the $r^{th}$ region or reporting group (r = 1,...,R). $Y^*_r$ can be estimated as

$$Y^*_r = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi} Y_{hi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi}} \quad (6)$$

where

$Y_{hi}$ = observed radon measurement for the $i^{th}$ eligible household in stratum h ($i = 1,..., n_h$, $h = 1, ..., H$):

$W_{hi}$ = sampling weight associated with $Y_{hi}$; and

$J_{rhi}$ = | 1 if $i^{th}$ eligible household in stratum h is in the $r^{th}$ region,
| 0 otherwise.

The estimated mean for all regions combined (i.e., the statewide estimate) is given by

$$Y^*_o = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi} Y_{hi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi}} \quad (7)$$

Similarly, define $P^*_r$ as the true proportion of eligible households in the $r^{th}$ region with radon levels exceeding X pCi/l. $P^*_r$ can be estimated as

$$P^*_r = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi} I_{xhi}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} J_{rhi} W_{hi}} \quad (8)$$

where $W_{hi}$ and $J_{rhi}$ are as previous defined and

$I_{xhi}$ = | 1 if measurement on $i^{th}$ eligible household in stratum h is
| greater than X pCi/l
| 0 otherwise.

The estimated proportion for all regions combined (i.e., the statewide estimate) is given by

$$P^*_o = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} W_{hi} I_{xhi}}{\sum_{n=1}^{H} \sum_{i=1}^{n_h} W_{hi}} \qquad (9)$$

# 4. Methodological Results

The survey methodology used during the fourth year of the State/EPA Radon Survey program was reviewed at four different levels :

- First, the coverage of each state survey was assessed. To do this four different estimates were compared of the number of owner-occupied single family housing units having a telephone, which was the approximate definition of the survey-eligible population. For each state, the survey estimate of this population size was compared to an estimate based on the 1980 Census counts for the state, to an estimate made using current counts from the Donnelley Marketing Service files from which most of the state samples were selected and to an estimate based on the Market Statistics' Projections.

- Second, the response rate and the participation rate obtained in each of the states was computed. These were simply the ratio of the estimated number participants to the estimated number of eligibles and the ratio of the usable canister readings to the number of eligibles.

- Third, the number of cases for which eligibility status was never determined was reviewed.

- Fourth, the Control/Screening Forms that were returned by the states were reviewed to identify the types of errors that the states made in carrying out the survey.

- Fifth, the types of problems that occurred throughout the course of all of the Year 4 State Radon Surveys were assessed to determine the modifications needed in the survey procedures.

In the sections that follow each of these assessments of the State Radon Survey methodology is discussed.

## 4.1 COVERAGE

The results of the coverage investigation are presented in Table 4-1. For each of the nine Year 4 states, the number of owner occupied single family housing units with a

telephone was estimated using 1980 decennial census information, using Donnelley file counts, using Market Statistics, and using State Radon Survey results. In constructing these estimates the percentage of housing units that were owner-occupied was available by state, but the percentage of owner-occupied housing units that were single unit structures was available only for the nation as a whole. The national average, of 94 percent of all owner-occupied housing being single unit structures, was therefore used in the calculations for each of the states. In addition, the nationwide estimate of 97 percent was used for the percentage of owner-occupied single structure housing units having a telephone.

Column 3 of Table 4-1 shows an estimate of the approximate number of survey-eligible housing units using 1980 census counts, and column 5 and 9 show comparable estimates made from the Donnelley file counts and the Market Statistics' estimates, respectively. The ratio of the Donnelley estimate to the Census estimate, shown in column 6, varies from a low of 0.49 for California and 0.55 for Nevada to a high of 0.83 for North Carolina, 0.84 for Nebraska, and 0.85 for Idaho. Column 7 shows comparable ratios for estimates of survey eligibles based on Donnelley file counts to estimates made from Market Statistics' data. These ratio vary from a low of 0.23 for California and Nevada to a high of 0.54 for Nebraska and Idaho. The two sets of ratios were calculated to get a very rough indicator of what might be missing using the Donnelley files as sampling frames, without using a supplementary procedure for picking up otherwise survey eligible housing units not linked to a Donnelley listing.

Column 15 shows the ratio of the number of survey eligibles in each state, as estimated from the survey itself, to the estimate made directly from the Donnelley frame counts. This ratio was calculated as a measure of the loss suffered because of movers and possibly because of households being difficult to reach. Recall that the procedures selected a sample of telephone numbers and the housing units linked to those numbers, regardless of whether the address was the same as was given in the frame. Therefore, housing units of movers were picked up, but not to the degree in which they were lost.

When someone moves, their telephone number is typically retired for a period of 6 months to a year, unless it is carried to the new home. Therefore, although a good many movers were reached at their new home, intrastate movers changing telephone numbers and those moving in from another state were lost if the move occurred after the directory cutoff date for Donnelley listings.

The ratio of survey-estimated survey eligibles to Donnelley-estimated survey eligibles ranged from a low of 0.62 for Hawaii and 0.72 for Louisiana, indicating some possible substantial loss because of movers, to highs near 1.00 for the remaining Year 4 states.

## 4.2 RESPONSE RATES

Approximate response and participation rates are presented in the bottom two rows of Table 4-2. The percentage of known survey-eligible housing units in which the respondent agreed to place a charcoal canister ranges from a low of 80 percent for Navajo Indians and 86 percent for Louisiana to highs of over 90 percent for most of the other surveys. Although nonrespondents in the state surveys were almost exclusively refusals, nonrespondents in the Montana Indian survey and Navajo Indian survey included a small number of refusals and a sizeable number of cases coded not-at-home, householder absent, or disability of householder precludes participation.

Participation rates show the percentage of known survey-eligible homes for which a usable canister reading was obtained. These percentages vary from a low of 62 percent for Louisiana to a high of 93 percent for the Montana Indian lands survey. The high figure for the latter group represents the success of the personal placement and retrieval procedures used in this survey. The highest participation rate for a state survey was 84 percent for the Nebraska telephone survey.

Although the average response rate for known eligibles for the nine Year 4 state surveys was about 90 percent, the average participation rate was only about 72 percent, a drop of

about 18 percentage points. Getting people to return their canisters immediately after exposing them for the designated period was an aspect of data collection that continued to be given a great deal of emphasis. States were encouraged to recontact people to whom a canister had been sent, but no reading received, to remind them to deploy their canister and to return immediately after exposure. Nevertheless, the loss due to failure to deploy and return canisters continued to be a major problem. The 18 percent average loss for the nine Year 4 state surveys was considerably greater than the 13 percent average loss that plagued the eight Year 3 state surveys. There was no ready explanation for this increase. Although the diffusion barrier charcoal canister was used in Year 4, instead of the open-faced charcoal canister that had been used in the previous three years, the two-day exposure period was the same for all four years of surveys.

## 4.3 UNKNOWN ELIGIBILITY STATUS

Most of the Year 4 states did an excellent job in returning all Control/Screening Forms for all of their activated waves. This aspect of the data collection process was emphasized in the Year 2, Year 3 and Year 4 training sessions because it had been found to be a major problem in Year 1. However there continued to be a large number of "eligibility unknown" cases and these were especially high for California, where about one-fifth of all activated sample cases were so classified.

In generating statistical estimates from the survey data, every sample case in every implemented sample wave must be accounted for, including every case for which a screening form is not returned and every case for which eligibility was not determined. Although these cases are classified as "eligibility status unknown," they cannot be ignored in the estimation process. Sampling weight calculations include adjustments for:

- That portion of the unknown-eligibility category of nonresponse estimated to be survey eligible, and
- The category of nonresponse due to failure of sample eligibles to participate in the survey.

These sampling weight adjustments were made in an attempt to reduce the possible bias caused by missing information for sample cases. However, no adjustment can eliminate the potential for such bias.

Table 4-1 Comparison of Estimates of Survey Eligibles

| | 1980 | | | 1989-90 Donnelley | | | |
|---|---|---|---|---|---|---|---|
| | Census | | | | | | |
| State | Number of Occupied Housing Units (1) | Percent Owner-Occupied (2) | Estimated Number of Owner-Occupied Single Family Housing Units with Telephone (3)* | Number of Housing Units with Telephone (4) | Estimated Number of Owner-Occupied Single Family Housing Units with Telephone (5)** | Ratio of Donnelley-Estimated Eligibles to Census-Estimated Eligibles (5) ÷ (3) = (6) | Ratio of Donnelley-Estimated Eligibles to Market Statistics' Estimated Eligibles (5) ÷ (9) = (7) |
| CA | 8,629,866 | 55.9 | 4,398,610 | 4,131,700 | 2,171,043 | 0.49 | 0.23 |
| HI | 294,052 | 51.7 | 138,616 | 221,925 | 107,851 | 0.78 | 0.34 |
| ID | 324,107 | 72.0 | 212,775 | 267,631 | 181,133 | 0.85 | 0.54 |
| LA | 1,411,788 | 65.5 | 843,161 | 975,212 | 600,438 | 0.71 | 0.41 |
| NE | 571,400 | 68.4 | 356,366 | 467,669 | 300,692 | 0.84 | 0.54 |
| NV | 304,327 | 59.6 | 165,381 | 163,006 | 91,322 | 0.55 | 0.23 |
| NC | 2,043,291 | 68.4 | 1,274,320 | 1,646,145 | 1,058,405 | 0.83 | 0.48 |
| OK | 1,118,561 | 70.7 | 721,072 | 777,975 | 517,027 | 0.72 | 0.44 |
| SC | 1,029,981 | 70.2 | 659,274 | 751,990 | 496,223 | 0.75 | 1.43 |

| | December 1988 Market Statistics | | | State Radon Survey Estimates | | | | |
|---|---|---|---|---|---|---|---|---|
| State | Number of Occupied Housing Units (8) | Estimated Number of Owner-Occupied Single Family Housing Units with Telephone (9)* | Ratio of Market Statistics' Estimated Eligibles to Census Estimate Eligibles (9) ÷ (3) = (10) | Sample Sizes (11) | Estimated Number of Survey Eligibles Housing Units (12) | Ratio of Survey-Estimated Eligibles to Census Estimate Eligibles (12) ÷ (3) = (13) | Ratio of Survey-Estimated Eligibles to Market Statistics (12) ÷ (9) = (14) | Ratio of Survey-Estimated Eligibles to Donnelley Estimate Eligibles (12) ÷ (5) = (15) |
| CA | 10,451,200 | 9,529,404 | 2.17 | 1,885 | 2,232,780 | 0.51 | 0.23 | 1.03 |
| HI | 351,800 | 320,771 | 2.31 | 523 | 67,044 | 0.48 | 0.21 | 0.62 |
| ID | 370,200 | 337,548 | 1.59 | 1,142 | 187,331 | 0.88 | 0.55 | 1.03 |
| LA | 1,602,800 | 1,461,433 | 1.73 | 1,314 | 432,162 | 0.51 | 0.30 | 0.72 |
| NE | 614,200 | 560,028 | 1.57 | 2,027 | 310,857 | 0.87 | 0.56 | 1.03 |
| NV | 433,500 | 395,265 | 2.39 | 1,562 | 93,004 | 0.56 | 0.24 | 1.02 |
| NC | 2,439,700 | 2,224,518 | 1.75 | 1,290 | 1,114,747 | 0.87 | 0.50 | 1.05 |
| OK | 1,279,400 | 1,166,557 | 1.62 | 1,637 | 538,309 | 0.75 | 0.46 | 1.04 |
| SC | 1,260,800 | 1,149,597 | 1.74 | 1,089 | 505,281 | 0.77 | 0.44 | 1.02 |

* Assuming 94 percent of owner-occupied units are one unit structures (1983). Also assuming 97 percent of housing units have a telephone (1981).

** Assuming column (2) percent owner-occupied and that 94 percent of these are one unit structures.

Table 4-2 Disposition of Sample Cases

| | CA | HI | ID | LA | NE | NV | NC | OK | SC | NM | MT Indians | Navajo Indians |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Waves Activated | 1-20 21-133 | 1-10 21-70 | 1-7 21-65 | 1-14 21-130 | 1-10 21-93 | 1-10 21-104 | 1-7 21-73 | – 21-97 | 1-7 21-73 | 1-11 21-100 | 1-4 21-48 | 1 2-10 |
| Sample Waves Used in Analysis | 1-20 21-125 | 1-10 21-70 | 1-7 21-65 | 1-13 21-130 | 1-10 21-93 | 1-10 21-104 | 1-7 21-73 | – 21-97 | 1-7 21-73 | 1-11 21-100 | partial 21-30 | 1 2-6 |
| C/S Forms Received | 6,457 | 3,000 | 2,598 | 6,161 | 4,148 | 4,700 | 3,000 | 3,849 | 2,998 | 4,506 | 517 | 4,647 |
| Cases Used in Analysis | 6,250 | 3,000 | 2,600 | 6,150 | 4,150 | 4,700 | 3,000 | 3,850 | 3,000 | 4,550 | 238 | 2,760 |
| Status Eligibility Status, Code Canister Acceptance | | | | | | | | | | | | |
| A1 Eligible, Accepted | 2,604 | 647 | 1,439 | 1,808 | 2,225 | 1,994 | 1,557 | 2,004 | 1,490 | 2,211 | 437 | 1,180 |
| A2 Eligible, Refused | 249 | 82 | 124 | 305 | 193 | 234 | 195 | 134 | 150 | 122 | 30 | 292* |
| C Eligibility unknown | 1,380 | 465 | 330 | 1,194 | 467 | 885 | 437 | 751 | 511 | 625 | 14 | (2,545)** |
| O Not Eligible | 1,892 | 1,491 | 535 | 2,368 | 938 | 1,174 | 583 | 641 | 605 | 1,066 | 35 | 581 |
| D Not a Residence | 382 | 315 | 170 | 486 | 325 | 413 | 228 | 319 | 242 | 482 | 1 | 49 |
| Total | 6,457 | 3,000 | 2,598 | 6,161 | 4,148 | 4,700 | 3,000 | 3,849 | 2,998 | 4,506 | 517 | 4,647 |
| U Usable Readings | 1,885 | 523 | 1,142 | 1,314 | 2,027 | 1,562 | 1,290 | 1,637 | 1,089 | 1,885 | 187 | 772 |
| Response Rate $(A_1/(A_1 + A_2)$ | 91.3% | 88.8% | 92.1% | 85.6% | 92.0% | 89.5% | 88.9% | 93.7% | 90.9% | 94.8% | 93.6% | 80.2% |
| Participation Rate $[O(U/A_1 + A_2)]$ | 69.2% | 71.9% | 73.1% | 62.2% | 83.8% | 70.1% | 73.6% | 76.6% | 66.4% | 80.8% | 92.6% | 77.8% |

* For the Navajo Indian Survey, this category includes not able to place because of absence or disability of householder.

** For the Navajo Indian Survey, these 2,545 cases include extra forms sent out to the field but not used.

# APPENDIX A

## Installation Procedures

# INSTALLATION PROCEDURES

## 1. EXTRACTING DATA FROM THE DISKETTE

The diskette you have received contains three files:

- **DATA.FIL** - a compressed version of the screening measurement data collected in one year of the EPA/State Residential Radon surveys.
- **EXTRACT.EXE** - an executable program to extract and store the expanded version of the survey data file on your hard disk. The extract program will run on any IBM-compatible personal computer using the MS-DOS operating system, Version 2.0 or higher.
- **READ_ME.1ST** - a copy of these instructions.

To expand the compressed file onto your hard disk, place the diskette in the appropriate drive and change to this drive. (For example, type **A:** then press the Enter key.) Run the program by typing the command **EXTRACT**, then press the Enter key. The program will ask where you want to store the expanded file. Respond by entering a full DOS pathname and filename to specify the drive, directory and name for the expanded file. For example, you may enter **C:\SURVEY\FILE1.DAT**. Note that the directory to which the file will be written (**C:\SURVEY**) must already exist on your hard disk. If the file (**FILE1.DAT**) already exists on the directory, you will be asked if you want to overwrite the file. Enter **Y** or **N**, as appropriate. The expanded file will be created under the filename and directory specified.

The program will ask if you want to extract specific State/Indian lands data from the survey data file. (Note: Read the file size considerations noted below before deciding how to extract the data.) To extract all of the data in the file, enter **A**. Enter **S** to extract only a subset of the data, rather than the entire file. You may select state codes from the list as instructed by the program. Note that the codes must be entered exactly as listed. After selecting the states, enter **1** to extract the file. If you make a mistake, enter **2** to re-enter the list of codes. You may enter **3** at any time to see the list of codes again, or **0** to exit the program.

## 2. SIZE CONSIDERATIONS

The entire expanded file for this diskette requires approximately 1.3 Megabytes of disk space. The expanded file is a standard DOS text file, with fixed-length records, one record for each house returning useable measurements. The expanded data file contains 99 ASCII text characters on each record, followed by carriage return and linefeed characters at the end of each line of text. A description of the layout of information on each record is included in the documentation for this diskette as Appendix B. The variable names listed there are the names used in EPA's analysis of the survey data.

The expanded file may be imported into a variety of DOS application programs for display and/or analysis. Most DOS applications can import DOS text files. Analysis of the data will require the use of an application program and a computer with sufficient memory available to handle a file of the required size. This should be considered when the Extract program is run. If data for all states on the disk are extracted into a single expanded file and your computer does not have additional extended or expanded memory beyond the now standard 640 Kilobytes of DOS memory, the large size of the expanded file may cause problems in many applications.

Another consideration is the number of lines (records) in the expanded file. While Excel for Windows can accommodate over 16,000 lines of data, many spreadsheet programs have a limit of approximately 8,000 lines. The entire expanded file exceeds 8,000 lines and an error will occur when importing the file into Lotus 123, for example, although sufficient memory may be available. If these size problems are a concern for your program or computer, we recommend extracting the data for each state into a separate file. The resulting expanded files for each state will be much smaller and problems due to size will be avoided.

## 3. ACCESSING DATA IN THE EXPANDED FILE

The expanded file is sorted by county within states, so that all records for a given county are

grouped together in the file. For users without access to more powerful software, selected portions of the data may be viewed and printed using any word processing program that accepts DOS text files as input. For example, in version 5.0 of Wordperfect this is accomplished by the [Control-F5, 1, 2] keystroke sequence. Select a smaller font or use the landscape page orientation to print all 99 columns of data.

To conserve disk space, the expanded file does not include blank spaces between adjacent entries on a record, so a simple printout of the file as received may difficult to read. It is also difficult to analyze the data using a word processing program. DOS spreadsheet and database application programs may be used to reformat, graph and/or analyze the data.

The expanded file may be imported into a Lotus 123 spreadsheet, for example, using the [/File, Import, Text] keystroke sequence, if sufficient memory is available. The specific variables on each record may be parsed into individual numeric and label cells using the [/Data, Parse, Format, Create] keystroke sequence to specify the columns with the desired information. Then set the Input and Output ranges from the data parse menu, followed by Go. Other spreadsheet and database packages have specific procedures for importing DOS text file specified in the user reference manual.

## 4. CONSIDERATIONS FOR DATA ANALYSIS

This file reports short-term screening level radon measurements, conducted in accordance with prevailing EPA protocols in effect in the year of the survey. The file contains one record for each surveyed home with a useable radon measurement collected during the survey. Some data fields may have missing entries on certain records. Although attempts were made to gather complete information on each useable radon test, it was not possible to complete all items for all surveyed homes. Missing data items are indicated by a blank data field or by a single period in the data field.

The radon concentrations were estimated using a laboratory counting procedure on the

exposed charcoal canisters, with a correction made for counts due to background radiation. This correction results in negative estimates of the radon concentration in some homes. These negative numbers should be considered a result of measurement error. In reality, radon concentrations are always non-negative.

The percent error variable recorded on the data file is the percentage measurement error reported by the EPA laboratory. This 2-sigma error bound was calculated based on the expected counting errors involved in the measurement process. No percentage measurement errors were reported by the laboratory for radon activities less than about 0.50 pCi/L. In the database the percent error variable is set to 0.0 on these records. For this variable, a percent error value of 0.0 should be treated as a missing value. In reality, the percentage measurement error associated with these measurements is very large.

The two problems noted above both derive from the lack of a specified Lower Limit of Detection (LLD) for the state survey data. One solution to both problems is to use the percent error variable to define the LLD for the radon activity variable. If the percent error is 0.0 and the radon activity is 0.5 pCi/L or less, then the radon activity measurement is below the LLD for the laboratory and its actual numeric value is meaningless. Alternatively, the negative activity values may be set to a small non-negative number, such as 0.05 pCi/L. This alternative method was used to calculate the survey statistics reported in this documentation.

# APPENDIX B

## Record Layout for State Residential Radon Surveys

Record Layout for State Residential Radon Surveys

| Variable | Position | Type | Length | Description |
|---|---|---|---|---|
| STATE | 1-2 | A | 2 | State Postal Abbreviation<br>(R5, R6, R7, RB, RC, RN are Indian Nations) |
| STATE2 | 3-4 | A | 2 | State Postal Abbreviation for Indian Land Surveys<br>(STATE = STATE2 for all other records) |
| STFIPS | 5-6 | N | 2 | State FIPS Code |
| ZIP | 7-11 | A | 5 | Zip Code |
| REGION | 12-13 | N | 2 | Analysis Region Code |
| TYPEBLDG | 14 | N | 1 | Type of Building<br>0 = unknown<br>1 = single family<br>2 = multi-family<br>3 = business<br>4 = school<br>5 = other |
| FLOOR | 15 | N | 1 | Floor Level<br>0 = basement<br>1 = first floor<br>2 = second floor or above<br>9 = unknown |
| ROOM | 16 | N | 1 | Type of Room<br>0 = unknown<br>1 = bedroom<br>2 = family room<br>3 = living room<br>4 = unfinished basement<br>5 = office<br>6 = classroom<br>7 = other |

Record Layout for State Residential Radon Surveys - continued

| Variable | Position | Type | Length | Description |
|---|---|---|---|---|
| BASEMENT | 17 | A | 1 | Is There a Basement in the Building?<br>blank = unknown<br>Y = Yes<br>N = No |
| WINDOOR | 18 | A | 1 | House Closed or Open During Test<br>blank = unknown<br>O = Open<br>C = Closed |
| REP | 19-20 | N | 2 | Replicate Number |
| STRATUM | 21-22 | N | 2 | Stratum Number |
| WAVE | 23-25 | N | 3 | Wave Number |
| STARTTM | 26-29 | N | 4 | Start Time of Test (HHMM) |
| STOPTM | 30-33 | N | 4 | Stop Time of Test (HHMM) |
| STARTDT | 34-39 | N | 6 | Start Date of Test (MMDDYY) |
| STOPDT | 40-45 | N | 6 | Stop Date of Test (MMDDYY) |
| ACTIVITY | 46-53 | N | 8.1 | Activity (pCi/L) |
| PCTERR | 54-61 | N | 8.1 | Percent Error (2-sigma) |
| ADJWT | 62-74 | N | 13.6 | Analysis Weight |
| DUPFLAG | 75 | N | 1 | Duplicate Flag<br>0 = activity from single canister<br>1 = average activity from duplicate canisters |
| ZIPFLAG | 76 | N | 1 | Flag for Zip Code (ZIP)<br>0 = believed accurate<br>1 = questionable |

Record Layout for State Residential Radon Surveys - continued

| Variable | Position | Type | Length | Description |
|---|---|---|---|---|
| CNTYFIPS | 77-79 | N | 3 | County FIPS Code |
| COUNTY | 80-99 | A | 20 | County Name |

# APPENDIX C

## Description of Sample Allocation Used for Each State

## CALIFORNIA (6)

Allocation #8 was used.
Expected DEFF = 2.913

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | CA03 (L) | 300 | 15.0 x |
| 2 | CA01 (H), CA02 (M) | 162 | 30.0 x |
| 3 | CA01 (H), CA03 (L) | 334 | 15.0 x |
| 4 | CA03 (L) | 259 | 4.0 x |
| 5 | CA01 (H) | 298 | 30.0 x |
| 6 | CA02 (M) CA03 (L) | 459 | 4.0 x |
| 7 | CA03 (L) | 519 | 15.0 x |
| 8 | CA03 (L) | 320 | 15.0 x |
| 9 | CA01 (H), CA02 (M), CA03 (L) | 350 | 1.0 x |
| | Total: | 3,000 | |

## HAWAII (15)

Allocation #3 was used.
Expected DEFF = 1.368

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | HI01 (H) | 150 | 3.8 x |
| 2 | HI01 (H) | 100 | 3.1 x |
| 3 | HI01 (H) | 75 | 4.7 x |
| 4 | HI01 (H) | 275 | 1.0 x |
| | Total: | 600 | |

## IDAHO (16)

Allocation #4 was used.
Expected DEFF = 1.138

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | ID01 (H) | 192 | 2.0 x |
| 2 | ID01 (H) | 197 | 3.0 x |
| 3 | ID01 (H) | 192 | 2.0 x |
| 4A | ID01 (H) | 42 | 2.0 x |
| 4B | ID01 (H) | 152 | 1.0 x |
| 5 | ID01 (H) | 196 | 2.0 x |
| 6A | ID01 (H) | 63 | 3.5 x |
| 6B | ID01 (H) | 156 | 2.0 x |
| 7A | ID01 (H) | 81 | 3.5 x |
| 7B | ID01 (H) | 127 | 2.0 x |
| | Total: | 1,400 | |

## LOUISIANA (22)

Allocation #4 was used.
Expected DEFF = 1.085

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1A | LA01 (H) | 233 | 3.0 x |
| 1B | LA01 (H) | 357 | 1.0 x |
| 2 | LA01 (H) | 430 | 1.5 x |
| 3A | LA01 (H) | 8 | 3.0 x |
| 3B | LA01 (H) | 466 | 1.5 x |
| 4 | LA01 (H) | 507 | 1.0 x |
| | Total: | 2,000 | |

## NEBRASKA (31)

Allocation #4 was used.
Expected DEFF = 2.167

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1A | NE01 (H) | 75 | 2.0 x |
| 1B | NE01 (H) | 374 | 1.0 x |
| 2 | NE01 (H) | 392 | 6.0 x |
| 3A | NE01 (H) | 118 | 18.0 x |
| 3B | NE01 (H) | 318 | 6.0 x |
| 4A | NE01 (H) | 56 | 18.0 x |
| 4B | NE01 (H) | 383 | 9.0 x |
| 5A | NE01 (H) | 25 | 9.0 x |
| 5B | NE01 (H) | 458 | 6.0 x |
| | Total: | 2,200 | |

## NEVADA (32)

Allocation #4 was used.
Expected DEFF = 2.670

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | NV01 (H) | 357 | 1.0 x |
| 2A | NV01 (H) | 107 | 45.1 x |
| 2B | NV01 (H) | 213 | 17.0 x |
| 3 | NV01 (H) | 238 | 5.0 x |
| 4 | NV01 (H) | 238 | 1.6 x |
| 5 | NV01 (H) | 237 | 17.0 x |
| 6 | NV01 (H) | 226 | 45.1 x |
| 7 | NV01 (H) | 228 | 17.0 x |
| 8 | NV01 (H) | 282 | 45.1 x |
| | | 2,125 | |

## NORTH CAROLINA (37)

Allocation #6 was used.
Expected DEFF = 1.106

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | NC01 (H) | 304 | 1.0 x |
| 2 | NC02 (MH) | 280 | 1.0 x |
| 3 | NC03 (M) | 306 | 1.0 x |
| 4 | NC04 (ML) | 271 | 2.1 x |
| 5 | NC05 (L) | 339 | 2.1 x |
| | Total: | 1,500 | |

## OKLAHOMA (40)

Allocation #4 was used.
Expected DEFF = 1.247

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1A | OK01 (H) | 45 | 5.5 x |
| 1B | OK01 (H) | 81 | 2.5 x |
| 1C | OK01 (H) | 175 | 1.0 x |
| 2 | OK01 (H) | 284 | 2.5 x |
| 3A | OK01 (H) | 47 | 5.5 x |
| 3B | OK01 (H) | 285 | 2.5 x |
| 4 | OK01 (H) | 270 | 2.5 x |
| 5 | OK01 (H) | 291 | 1.0 x |
| 6 | OK01 (H) | 319 | 2.5 x |
| 7 | OK01 (H) | 205 | 2.5 x |
| | Total: | 2,000 | |

## SOUTH CAROLINA (45)

Allocation #5 was used.
Expected DEFF = 1.00

| Stratum | Geological Classification Expected Radon Level | Canisters | Relative Sampling Rates |
|---|---|---|---|
| 1 | SC01 (H) | 703 | 1.0 x |
| 2 | SC01 (H) | 184 | 1.0 x |
| 3 | SC01 (H) | 157 | 1.0 x |
| 4 | SC01 (H) | 456 | 1.0 x |
| | Total: | 1,500 | |

BILLINGS, MT INDIAN

Allocation #1 was used.
Expected DEFRF = 1.379

| Stratum | Canisters | Related Sampling Rates |
|---|---|---|
| 1 | 200 | 1.0 x |
| 2 | 200 | 1.8 x |
| 3 | 200 | 2.8 x |
| 4 | 200 | 7.3 x |
| Total: | 800 | |

Table C-1 Distribution of Canisters per County for California

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ALAMEDA | 6 | 60 |
| ALPINE | 5 | 0 |
| AMADOR | 5 | 15 |
| BUTTE | 3 | 44 |
| CALAVERAS | 5 | 18 |
| COLUSA | 3 | 2 |
| CONTRA COSTA | 4 | 60 |
| DEL NORTE | 1 | 8 |
| EL DORADO | 5 | 34 |
| FRESNO | 7 | 106 |
| GLENN | 3 | 10 |
| HUMBOLDT | 1 | 36 |
| IMPERIAL | 9 | 2 |
| INYO | 5 | 1 |
| KERN | 7 | 100 |
| KINGS | 7 | 12 |
| LAKE | 3 | 16 |
| LASSEN | 2 | 18 |
| LOS ANGELES | 9 | 69 |
| MADERA | 7 | 24 |
| MARIN | 1 | 58 |
| MARIPOSA | 5 | 9 |
| MENDOCINO | 1 | 17 |
| MERCED | 4 | 10 |
| MODOC | 2 | 5 |
| MONO | 5 | 2 |
| MONTEREY | 6 | 20 |
| NAPA | 3 | 29 |
| NEVADA | 3 | 26 |
| ORANGE | 9 | 31 |
| PLACER | 5 | 82 |
| PLUMAS | 3 | 11 |
| RIVERSIDE | 9 | 24 |
| SACRAMENTO | 4 | 55 |
| SAN BENITO | 6 | 2 |
| SAN BERNARDINO | 9 | 17 |
| SAN DIEGO | 9 | 39 |
| SAN FRANCISCO | 6 | 20 |
| SAN JOAQUIN | 4 | 22 |
| SAN LUIS OBISPO | 6 | 15 |
| SAN MATEO | 6 | 38 |
| SANTA BARBARA | 8 | 90 |
| SANTA CLARA | 6 | 77 |
| SANTA CRUZ | 6 | 10 |
| SHASTA | 2 | 79 |

Table C-1 Distribution of Canisters per County for California (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| SIERRA | 3 | 2 |
| SISKIYOU | 2 | 27 |
| SOLANO | 3 | 43 |
| SONOMA | 1 | 82 |
| STANISLAUS | 4 | 14 |
| SUTTER | 3 | 15 |
| TEHAMA | 3 | 17 |
| TRINITY | 2 | 6 |
| TULARE | 7 | 63 |
| TUOLUMNE | 5 | 24 |
| VENTURA | 8 | 140 |
| YOLO | 4 | 14 |
| YUBA | 3 | 15 |

Table C-1 Distribution of Canisters per County for Hawaii

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| HAWAII | 1 | 138 |
| HONOLULU | 4 | 257 |
| KALAWAO | 0 | 0 |
| KAUAI | 3 | 49 |
| MAUI | 2 | 79 |

Table C-1 Distribution of Canisters per County for Idaho

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ADA | 4 | 769 |
| ADAMS | 3 | 4 |
| BANNOCK | 6 | 16 |
| BEAR LAKE | 6 | 10 |
| BENEWAH | 1 | 3 |
| BINGHAM | 6 | 10 |
| BLAINE | 5 | 6 |
| BOISE | 4 | 1 |
| BONNER | 1 | 17 |
| BONNEVILLE | 7 | 21 |
| BOUNDARY | 1 | 6 |
| BUTTE | 6 | 7 |
| CAMAS | 5 | 1 |
| CANYON | 3 | 37 |
| CARIBOU | 6 | 19 |
| CASSIA | 5 | 15 |
| CLARK | 7 | 2 |
| CLEARWATER | 2 | 8 |
| CUSTER | 7 | 5 |
| ELMORE | 4 | 4 |
| FRANKLIN | 6 | 16 |
| FREMONT | 7 | 1 |
| GEM | 3 | 5 |
| GOODING | 5 | 5 |
| IDAHO | 2 | 18 |
| JEFFERSON | 7 | 2 |
| JEROME | 5 | 3 |
| KOOTENAI | 1 | 29 |
| LATAH | 2 | 55 |
| LEMHI | 7 | 17 |
| LEWIS | 2 | 2 |
| LINCOLN | 5 | 1 |
| MADISON | 7 | 32 |
| MINIDOKA | 5 | 9 |
| NEZ PERCE | 2 | 50 |
| ONEIDA | 6 | 0 |
| OWYHEE | 3 | 2 |
| PAYETTE | 3 | 5 |
| POWER | 6 | 2 |
| SHOSHONE | 1 | 11 |
| TETON | 7 | 6 |
| TWIN FALLS | 5 | 30 |
| VALLEY | 4 | 0 |
| WASHINGTON | 3 | 4 |

Table C-1 Distribution of Canisters per County for Louisiana

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ACADIA | 2 | 13 |
| ALLEN | 2 | 5 |
| ASCENSION | 3 | 23 |
| ASSUMPTION | 4 | 5 |
| AVOYELLES | 1 | 6 |
| BEAUREGARD | 2 | 8 |
| BIENVILLE | 1 | 15 |
| BOSSIER | 1 | 35 |
| CADDO | 1 | 83 |
| CALCASIEU | 2 | 60 |
| CALDWELL | 1 | 13 |
| CAMERON | 2 | 2 |
| CATAHOULA | 1 | 7 |
| CLAIBORNE | 1 | 16 |
| CONCORDIA | 1 | 7 |
| DE SOTO | 1 | 6 |
| EAST BATON ROUGE | 3 | 170 |
| EAST CARROLL | 1 | 9 |
| EAST FELICIANA | 3 | 5 |
| EVANGELINE | 2 | 6 |
| FRANKLIN | 1 | 9 |
| GRANT | 1 | 9 |
| IBERIA | 2 | 12 |
| IBERVILLE | 3 | 7 |
| JACKSON | 1 | 2 |
| JEFFERSON | 4 | 104 |
| JEFFERSON DAVIS | 2 | 8 |
| LA SALLE | 1 | 10 |
| LAFAYETTE | 2 | 71 |
| LAFOURCHE | 4 | 12 |
| LINCOLN | 1 | 11 |
| LIVINGSTON | 3 | 29 |
| MADISON | 1 | 2 |
| MOREHOUSE | 1 | 12 |
| NATCHITOCHES | 1 | 27 |
| ORLEANS | 4 | 51 |
| OUACHITA | 1 | 44 |
| PLAQUEMINES | 4 | 3 |
| POINTE COUPEE | 3 | 6 |
| RAPIDES | 1 | 47 |
| RED RIVER | 1 | 4 |
| RICHLAND | 1 | 8 |
| SABINE | 1 | 8 |
| ST. BERNARD | 4 | 18 |
| ST. CHARLES | 4 | 15 |

Table C-1 Distribution of Canisters per County for Louisiana (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ST. HELENA | 3 | 0 |
| ST. JAMES | 4 | 12 |
| ST. JOHN | 4 | 11 |
| ST. LANDRY | 2 | 28 |
| ST. MARTIN | 2 | 8 |
| ST. MARY | 2 | 17 |
| ST. TAMMANY | 3 | 73 |
| TANGIPAHOA | 3 | 18 |
| TENSAS | 1 | 6 |
| TERREBONNE | 4 | 35 |
| UNION | 1 | 12 |
| VERMILION | 2 | 13 |
| VERNON | 1 | 15 |
| WASHINGTON | 3 | 7 |
| WEBSTER | 1 | 14 |
| WEST BATON ROUGE | 3 | 7 |
| WEST CARROLL | 1 | 7 |
| WEST FELICIANA | 3 | 3 |
| WINN | 1 | 5 |

Table C-1 Distribution of Canisters per County for Nebraska

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ADAMS | 5 | 75 |
| ANTELOPE | 2 | 20 |
| ARTHUR | 4 | 4 |
| BANNER | 4 | 6 |
| BLAINE | 3 | 5 |
| BOONE | 2 | 17 |
| BOX BUTTE | 4 | 37 |
| BOYD | 2 | 11 |
| BROWN | 3 | 6 |
| BUFFALO | 5 | 81 |
| BURT | 2 | 13 |
| BUTLER | 1 | 9 |
| CASS | 1 | 10 |
| CEDAR | 2 | 32 |
| CHASE | 3 | 15 |
| CHERRY | 3 | 40 |
| CHEYENNE | 4 | 45 |
| CLAY | 5 | 14 |
| COLFAX | 1 | 10 |
| CUMING | 2 | 26 |
| CUSTER | 3 | 40 |
| DAKOTA | 2 | 27 |
| DAWES | 4 | 34 |
| DAWSON | 3 | 40 |
| DEUEL | 4 | 5 |
| DIXON | 2 | 17 |
| DODGE | 1 | 16 |
| DOUGLAS | 1 | 148 |
| DUNDY | 3 | 7 |
| FILLMORE | 1 | 6 |
| FRANKLIN | 5 | 14 |
| FRONTIER | 3 | 8 |
| FURNAS | 3 | 12 |
| GAGE | 1 | 10 |
| GARDEN | 4 | 28 |
| GARFIELD | 5 | 9 |
| GOSPER | 3 | 4 |
| GRANT | 4 | 2 |
| GREELEY | 5 | 18 |
| HALL | 5 | 109 |
| HAMILTON | 5 | 18 |
| HARLAN | 3 | 8 |
| HAYES | 3 | 8 |
| HITCHCOCK | 3 | 10 |
| HOLT | 2 | 34 |
| HOOKER | 4 | 15 |
| HOWARD | 5 | 13 |

Table C-1 Distribution of Canisters per County for Nebraska (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| JEFFERSON | 1 | 7 |
| JOHNSON | 1 | 1 |
| KEARNEY | 5 | 17 |
| KEITH | 4 | 31 |
| KEYA PAHA | 3 | 6 |
| KIMBALL | 4 | 17 |
| KNOX | 2 | 25 |
| LANCASTER | 1 | 74 |
| LINCOLN | 3 | 77 |
| LOGAN | 3 | 11 |
| LOUP | 3 | 6 |
| MADISON | 2 | 89 |
| MCPHERSON | 3 | 4 |
| MERRICK | 5 | 21 |
| MORRILL | 4 | 26 |
| NANCE | 5 | 16 |
| NEMAHA | 1 | 7 |
| NUCKOLLS | 5 | 19 |
| OTOE | 1 | 7 |
| PAWNEE | 1 | 2 |
| PERKINS | 3 | 9 |
| PHELPS | 3 | 24 |
| PIERCE | 2 | 14 |
| PLATTE | 1 | 11 |
| POLK | 1 | 6 |
| RED WILLOW | 3 | 25 |
| RICHARDSON | 1 | 7 |
| ROCK | 3 | 15 |
| SALINE | 1 | 9 |
| SARPY | 1 | 33 |
| SAUNDERS | 1 | 8 |
| SCOTTS BLUFF | 4 | 113 |
| SEWARD | 1 | 7 |
| SHERIDAN | 4 | 33 |
| SHERMAN | 5 | 8 |
| SIOUX | 4 | 6 |
| STANTON | 2 | 11 |
| THAYER | 1 | 6 |
| THOMAS | 3 | 10 |
| THURSTON | 2 | 4 |
| VALLEY | 5 | 13 |
| WASHINGTON | 1 | 8 |
| WAYNE | 2 | 18 |
| WEBSTER | 5 | 12 |
| WHEELER | 5 | 6 |
| YORK | 1 | 12 |

Table C-1 Distribution of Canisters per County for Nevada

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| CARSON CITY | 3 | 64 |
| CHURCHILL | 5 | 110 |
| CLARK | 1 | 188 |
| DOUGLAS | 3 | 52 |
| ELKO | 7 | 185 |
| ESMERALDA | 2 | 11 |
| EUREKA | 6 | 21 |
| HUMBOLDT | 8 | 204 |
| LANDER | 5 | 40 |
| LINCOLN | 2 | 103 |
| LYON | 3 | 53 |
| MINERAL | 2 | 54 |
| NYE | 2 | 120 |
| PERSHING | 5 | 6 |
| STOREY | 3 | 3 |
| WASHOE | 4 | 154 |
| WHITE PINE | 6 | 194 |

Table C-1. Distribution of Canisters per County for North Carolina

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ALAMANCE | 2 | 12 |
| ALEXANDER | 4 | 15 |
| ALLEGHANY | 5 | 9 |
| ANSON | 2 | 2 |
| ASHE | 5 | 9 |
| AVERY | 5 | 7 |
| BEAUFORT | 1 | 7 |
| BERTIE | 1 | 1 |
| BLADEN | 1 | 2 |
| BRUNSWICK | 1 | 4 |
| BUNCOMBE | 5 | 94 |
| BURKE | 5 | 33 |
| CABARRUS | 3 | 13 |
| CALDWELL | 5 | 38 |
| CAMDEN | 1 | 1 |
| CARTERET | 1 | 7 |
| CASWELL | 3 | 2 |
| CATAWBA | 4 | 62 |
| CHATHAM | 2 | 5 |
| CHEROKEE | 5 | 8 |
| CHOWAN | 1 | 2 |
| CLAY | 5 | 6 |
| CLEVELAND | 4 | 42 |
| COLUMBUS | 1 | 9 |
| CRAVEN | 1 | 4 |
| CUMBERLAND | 1 | 13 |
| CURRITUCK | 1 | 2 |
| DARE | 1 | 3 |
| DAVIDSON | 3 | 20 |
| DAVIE | 4 | 17 |
| DUPLIN | 1 | 7 |
| DURHAM | 2 | 11 |
| EDGECOMBE | 1 | 4 |
| FORSYTH | 3 | 31 |
| FRANKLIN | 2 | 3 |
| GASTON | 4 | 73 |
| GATES | 1 | 0 |
| GRAHAM | 5 | 5 |
| GRANVILLE | 2 | 8 |
| GREENE | 1 | 1 |
| GUILFORD | 3 | 41 |
| HALIFAX | 2 | 3 |
| HARNETT | 2 | 6 |
| HAYWOOD | 5 | 32 |
| HENDERSON | 5 | 45 |

Table C-1 Distribution of Canisters per County for North Carolina (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| HERTFORD | 1 | 3 |
| HOKE | 1 | 1 |
| HYDE | 1 | 1 |
| IREDELL | 4 | 52 |
| JACKSON | 5 | 13 |
| JOHNSTON | 2 | 9 |
| JONES | 1 | 1 |
| LEE | 2 | 5 |
| LENOIR | 1 | 3 |
| LINCOLN | 4 | 29 |
| MACON | 5 | 14 |
| MADISON | 5 | 6 |
| MARTIN | 1 | 3 |
| MCDOWELL | 5 | 15 |
| MECKLENBURG | 3 | 55 |
| MITCHELL | 5 | 5 |
| MONTGOMERY | 2 | 3 |
| MOORE | 2 | 5 |
| NASH | 2 | 8 |
| NEW HANOVER | 1 | 10 |
| NORTHAMPTON | 1 | 4 |
| ONSLOW | 1 | 5 |
| ORANGE | 2 | 12 |
| PAMLICO | 1 | 3 |
| PASQUOTANK | 1 | 4 |
| PENDER | 1 | 5 |
| PERQUIMANS | 1 | 1 |
| PERSON | 2 | 1 |
| PITT | 1 | 10 |
| POLK | 4 | 9 |
| RANDOLPH | 2 | 8 |
| RICHMOND | 2 | 5 |
| ROBESON | 1 | 10 |
| ROCKINGHAM | 3 | 10 |
| ROWAN | 3 | 10 |
| RUTHERFORD | 4 | 28 |
| SAMPSON | 1 | 5 |
| SCOTLAND | 1 | 1 |
| STANLY | 3 | 5 |
| STOKES | 4 | 12 |
| SURRY | 5 | 36 |
| SWAIN | 5 | 2 |
| TRANSYLVANIA | 5 | 17 |
| TYRRELL | 1 | 1 |
| UNION | 3 | 7 |

Table C-1 Distribution of Canisters per County for North Carolina (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| VANCE | 2 | 3 |
| WAKE | 2 | 49 |
| WARREN | 2 | 0 |
| WASHINGTON | 1 | 1 |
| WATAUGA | 5 | 18 |
| WAYNE | 1 | 3 |
| WILKES | 5 | 23 |
| WILSON | 1 | 5 |
| YADKIN | 4 | 12 |
| YANCEY | 5 | 5 |

Table C-1 Distribution of Canisters per County for Oklahoma

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ADAIR | 2 | 4 |
| ALFALFA | 7 | 6 |
| ATOKA | 3 | 5 |
| BEAVER | 7 | 8 |
| BECKHAM | 6 | 15 |
| BLAINE | 7 | 13 |
| BRYAN | 3 | 21 |
| CADDO | 6 | 26 |
| CANADIAN | 5 | 23 |
| CARTER | 3 | 28 |
| CHEROKEE | 2 | 20 |
| CHOCTAW | 3 | 13 |
| CIMARRON | 7 | 3 |
| CLEVELAND | 5 | 31 |
| COAL | 3 | 5 |
| COMANCHE | 6 | 64 |
| COTTON | 6 | 4 |
| CRAIG | 1 | 20 |
| CREEK | 4 | 37 |
| CUSTER | 6 | 23 |
| DELAWARE | 2 | 23 |
| DEWEY | 7 | 6 |
| ELLIS | 7 | 6 |
| GARFIELD | 7 | 51 |
| GARVIN | 3 | 25 |
| GRADY | 6 | 30 |
| GRANT | 7 | 2 |
| GREER | 6 | 1 |
| HARMON | 6 | 3 |
| HARPER | 7 | 7 |
| HASKELL | 3 | 6 |
| HUGHES | 4 | 12 |
| JACKSON | 6 | 16 |
| JEFFERSON | 6 | 5 |
| JOHNSTON | 3 | 15 |
| KAY | 7 | 48 |
| KINGFISHER | 7 | 10 |
| KIOWA | 6 | 14 |
| LATIMER | 3 | 8 |
| LE FLORE | 3 | 25 |
| LINCOLN | 4 | 20 |
| LOGAN | 5 | 4 |
| LOVE | 3 | 8 |
| MAJOR | 7 | 11 |
| MARSHALL | 3 | 11 |

Table C-1 Distribution of Canisters per County for Oklahoma (Continued)

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| MAYES | 2 | 30 |
| MCCLAIN | 6 | 23 |
| MCCURTAIN | 3 | 25 |
| MCINTOSH | 2 | 6 |
| MURRAY | 3 | 7 |
| MUSKOGEE | 2 | 48 |
| NOBLE | 7 | 12 |
| NOWATA | 1 | 13 |
| OKFUSKEE | 4 | 13 |
| OKLAHOMA | 5 | 155 |
| OKMULGEE | 2 | 26 |
| OSAGE | 4 | 27 |
| OTTAWA | 2 | 28 |
| PAWNEE | 4 | 10 |
| PAYNE | 4 | 38 |
| PITTSBURG | 3 | 38 |
| PONTOTOC | 3 | 27 |
| POTTAWATOMIE | 4 | 40 |
| PUSHMATAHA | 3 | 9 |
| ROGER MILLS | 6 | 4 |
| ROGERS | 1 | 27 |
| SEMINOLE | 4 | 8 |
| SEQUOYAH | 2 | 10 |
| STEPHENS | 6 | 24 |
| TEXAS | 7 | 20 |
| TILLMAN | 6 | 5 |
| TULSA | 1 | 127 |
| WAGONER | 2 | 16 |
| WASHINGTON | 1 | 51 |
| WASHITA | 6 | 9 |
| WOODS | 7 | 8 |
| WOODWARD | 7 | 17 |

Table C-1 Distribution of Canisters per County for South Carolina

| COUNTY | REGION | # CANISTERS |
|---|---|---|
| ABBEVILLE | 1 | 7 |
| AIKEN | 2 | 49 |
| ALLENDALE | 4 | 3 |
| ANDERSON | 1 | 56 |
| BAMBERG | 4 | 2 |
| BARNWELL | 4 | 6 |
| BEAUFORT | 3 | 26 |
| BERKELEY | 4 | 24 |
| CALHOUN | 4 | 4 |
| CHARLESTON | 3 | 74 |
| CHEROKEE | 1 | 10 |
| CHESTER | 1 | 14 |
| CHESTERFIELD | 2 | 14 |
| CLARENDON | 4 | 6 |
| COLLETON | 4 | 11 |
| DARLINGTON | 4 | 23 |
| DILLON | 4 | 4 |
| DORCHESTER | 4 | 28 |
| EDGEFIELD | 2 | 5 |
| FAIRFIELD | 2 | 6 |
| FLORENCE | 4 | 37 |
| GEORGETOWN | 4 | 15 |
| GREENVILLE | 1 | 102 |
| GREENWOOD | 2 | 24 |
| HAMPTON | 4 | 6 |
| HORRY | 4 | 48 |
| JASPER | 4 | 0 |
| KERSHAW | 2 | 9 |
| LANCASTER | 2 | 18 |
| LAURENS | 1 | 19 |
| LEE | 4 | 7 |
| LEXINGTON | 1 | 62 |
| MARION | 4 | 10 |
| MARLBORO | 4 | 5 |
| MCCORMICK | 2 | 2 |
| NEWBERRY | 1 | 11 |
| OCONEE | 1 | 27 |
| ORANGEBURG | 4 | 27 |
| PICKENS | 1 | 31 |
| RICHLAND | 1 | 87 |
| SALUDA | 2 | 5 |
| SPARTANBURG | 1 | 78 |
| SUMTER | 4 | 19 |
| UNION | 2 | 13 |
| WILLIAMSBURG | 4 | 11 |
| YORK | 1 | 44 |

# APPENDIX D

## Regional Radon Coordinators and Sources of Information Concerning Other State-Wide Radon Studies

## Regional Radon Coordinators

| EPA REGION | REGIONAL OFFICE | CONTACT |
|---|---|---|
| 1 | U.S. Environmental Protection Agency<br>John F. Kennedy Federal Building<br>Room 2311<br>Boston, MA 02203 | Mona Haywood<br>(617) 565-9402 |
| 2 | U.S. Environmental Protection Agency<br>26 Federal Plaza<br>Room 1137-L<br>New York, NY 10278 | Lorainne Koehler<br>(212) 264-0546 |
| 3 | U.S. Environmental Protection Agency<br>(3AM12)<br>841 Chestnut Street<br>Philadelphia, PA 19107 | Lewis Felleisen<br>(215) 597-8326 |
| 4 | U.S. Environmental Protection Agency<br>345 Courtland Street, NE<br>Atlanta, GA 30365 | Paul Wagner<br>(404) 347-3907 |
| 5 | U.S. Environmental Protection Agency<br>Mail Code (AT-18J)<br>77 West Jackson Blvd.<br>Chicago, IL 60604 | Julie Beckman<br>(312) 886-6063 |
| 6 | U.S. Environmental Protection Agency<br>Air Enforcement Branch (6T-E)<br>1445 Ross Avenue<br>Dallas, TX 75202 | Michael Miller<br>(214) 655-7550 |
| 7 | U.S. Environmental Protection Agency<br>726 Minnesota Avenue<br>Kansas City, KS 66101 | Bob Hunt<br>(913) 551-7611 |
| 8 | U.S. Environmental Protection Agency<br>(8HWM-RP) Suite 500<br>999 18th Street<br>Denver, CO 80202 | Milton W. Lammering<br>(303) 293-1440 |
| 9 | U.S. Environmental Protection Agency<br>(A1-1)<br>75 Hawthorne Street<br>San Francisco, CA 94105 | Louise Hill<br>(415) 744-1046 |
| 10 | U.S. Environmental Protection Agency<br>(AT-082)<br>1200 Sixth Avenue<br>Seattle, WA 98101 | Misha Vakoc<br>(206) 553-7299 |

| Sources of Information Concerning Other State-Wide Radon Studies | | |
|---|---|---|
| STATE | AGENCY | CONTACT |
| New Jersey | Department of Environmental Protection<br>729 Alexander Road<br>Princeton, NJ 08540 | Robert Stern<br>(800) 648-0394<br>(609) 987-6402 |
| New York | State Health Department<br>Bureau of Environmental Radiation Protection<br>Corning Tower<br>Albany, NY 12237 | Laurence Keefe<br>(800) 458-1158<br>(518) 458-6450 |
| North Carolina | Department of Human Resources<br>Radiation Protection Section<br>701 Barbour Drive<br>Raleigh, NC 27603-2008 | Dr. Felix Fong<br>(919) 733-4283 |
| Idaho | Department of Health and Welfare<br>Bureau of Preventive Medicine<br>450 West State Street<br>Boise, ID 83720 | Janne Mitten<br>(208) 334-5927 |
| Florida | Department of Health and Rehabilitative Services<br>1317 Winewood Boulevard<br>Tallahassee, FL 32399-0700 | N. Michael Gilly<br>(800) 543-8279<br>(904) 488-1525 |
| South Carolina | Department of Health and Environmental Control<br>Bureau of Radiological Health<br>2600 Bull Street<br>Colombia, SC 29201 | Nolan Bivens<br>(803) 734-4700 |
| Oregon | Department of Human Services<br>Health Division<br>1400 SW 5th Avenue<br>Portland, OR 97201 | Ray Paris<br>(503) 229-5797 |
| Washington | Department of Health<br>Office of Radiation Protection<br>Airdustrial Building 5, LE-13<br>Olympia, WA 98504 | Robert Mooney<br>(206) 586-3303 |

| STATE | AGENCY | CONTACT |
|---|---|---|
| Montana | Department of Health and<br>Environmental Sciences<br>Cogswell Building<br>Helena, MT 59620 | Adrian Howe<br>(406) 444-3671 |
| New Hampshire | Division of Public Health Serv.<br>Bureau of Radiological Health<br>6 Hazen Drive<br>Concord, NH 03301 | Joy Hanington<br>(603) 271-4674 |
| Virginia | Department of Health<br>Bureau of Radiological Health<br>109 Governor Street<br>Richmond, VA 23219 | Leslie Foldesi<br>(800) 468-0138<br>(804) 786-5932 |
| Nevada | Department of Human Resources<br>Radiological Health Section<br>505 East King Street, Rm. 203<br>Carson City, NV 89710 | Stan Marshall<br>(702) 885-5394 |
| Louisiana | Louisiana Nuclear Energy Division<br>Department of Environmental Qual.<br>P.O. Box 14690<br>Baton Rouge, LA 70898 | Jay Mason<br>(504) 925-4518 |